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by

Ⓒ HSU SAMUEL WANG

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Bruce L Derwing

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Date 19 August 1985

Dedicated to
Mother and Hsiu Yü
獻給　母親和秀鈺

Abstract

This thesis investigates the nature of the productivity of the vowel alternations which the theoretical linguists try to characterize by the vowel shift rule. Previous experimental works relevant to this question are first examined. From these it was found that the vowel shift phenomenon is not an automatic phonological process, and the productivity can only be obtained by specifically requiring the subjects to vary the vowel. This study takes these as the starting point, and moves on to investigate how this limited productivity can be realistically characterized. Three experiments were conducted: a Preference Test, a Production Test, and a Concept Formation Test. The results of the Preference Test manifested vowel shift and no vowel shift (tense and lax alternation) activities. Analogy also showed strong influence in this task. In the Production Test, it was found that the vowel alternations are heavily object-oriented, depending on the morphological process involved. Still, in the Nominalization part of this test, where the subjects were asked to change the vowel while adding *-ity* to the adjective stem, the VS type of source-oriented alternations also demonstrated strength. In the Concept Formation Test, the subjects typically accepted [uw-ʌ], and rejected [aw-ʌ] and [ɔy-ʌ] as part of the vowel alternation phenomenon. It is suggested that the phenomenon had its origin in the speaker's recognition that a vowel letter can be pronounced in different ways, and in most of the alternation patterns which have been accepted as part of the vowel alternation phenomenon, a phonological link has been developed without the mediation of orthography, except the [uw-ʌ] pair. It is also found that the [aw-ʌ] alternation is not supported by the results in the three experiments, a fact which has been repeatedly demonstrated by previous psycholinguistic experiments. The thesis concludes that the way the phenomenon is traditionally handled by the theorists is doubtful. Instead the thesis proposes to characterize the relationships at the segmental level, and to adopt the model of "phonetic patterning" to express the relationships.

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Chapter 1

Introduction

One of the major goals of the transformational-generative theory of grammar is to express the structural relatedness of two linguistic forms. Thus, in most versions of the theory, the following two sentences are taken as related by a Passivization Transformation:

The car hit John.
John was hit by the car.

This general practice has been carried over from syntax to phonology. While the structural phonemicists associate various phonetically similar non-contrastive variations in terms of the notion of the "taxonomic phoneme", the generative phonologists attempted to push the relationship to a more "abstract" level and tie together more disparate forms such as [ay] and [ɪ] (as in *divine* and *divinity*) by assigning both vowels to a common "systematic phoneme" /ī/. More significantly, like Sapir (1933) in the structuralist tradition, many generative phonologists have claimed that the underlying phonological representations thus postulated are psychologically real. As Chomsky and Halle specifically said in their monumental book *The Sound Pattern of English* (1968; henceforth SPE),

> ...we use the term "grammar" to refer both to the system of rules represented in the mind of the speaker-hearer, a system which is normally acquired

> in early childhood and used in the production and interpretation of utterances, and to the theory that the linguist constructs as *a hypothesis concerning the actual internalized grammar of the speaker-hearer*. (p.4; italics added)

With such an assumption, it is natural to expect modern linguistic theory to seek to reflect psychologically true generalizations about the knowledge or abilities of typical speaker-hearers. In other words, the theoretical linguistic formulations are true to the extent that they express generalizations that are realizable and realized by the speaker-hearer in his language operations. Bearing this goal in mind, this thesis investigates the reality of a rule which Chomsky and Halle described as the "central problem in the noncyclic phonology of English" (SPE, p.178) and "without doubt the pivotal process of Modern English phonology" (SPE, p.187) — the English Vowel Shift Rule (or VS Rule).

1.1 The Status of the English Vowel Shift Rule

Since the publication of SPE, there has been much discussion on the formulation and the psychological status of the vowel shift analysis proposed in the book. This section sketches the formulation of the rule and traces its development in the more recent work of Halle (1977) and Halle and Mohanan (1985). It is understood that there have been a number of other important alternative proposals to the formulation of the rule, among them W. Wang (1968), Ladefoged (1971), Krohn (1972a) and Schane (1974). But as this thesis is not concerned with the formulation of the rule itself, and as these alternative proposals do not differ from SPE on the question of which vowel alternations are to be accounted for, these alternative formulations of the rule need not be considered here.

The vowel shift rule proposed by Chomsky and Halle was intended to accomodate the supposed phonological relatedness exhibited by the following pairs of vowels and illustrative examples:

[ay-ɪ]	divine-divinity
[iy-ɛ]	serene-serenity
[ey-æ]	sane-sanity
[aw-ʌ]	profound-profundity
[ow-ɔ]	verbose-verbosity
[uw-ɔ][1]	lose-lost

It is important to notice that these vowel alternation patterns are regarded as "phonological processes" because they are observed in a variety of morphological constructions. For example, the [ay-ɪ] alternation can be observed in adjective-noun pairs (*div_ine-div_inity*); verb-adjective pairs (*def_ine-def_initive*); verb-noun pairs

---

[1] There have been some disputes on this "sixth pair" — [uw-ɔ] (see footnote 4 on p.7). A phonetic note about the dialect under investigation is that the distinction between the vowels [ɔ] and [a] is neutralized in most environments. Since the "o" in both *verbosity* and *lost* is pronounced with a certain degree of lip rounding, I will use the symbol [ɔ] to represent this vowel.

(*decide-decision*); noun singular-plural pairs (*child-children*); and verb present-past pairs (*slide-slid*). Therefore the environments of the alternation need not be defined morphologically, and the generalization might be captured by a phonologically motivated rule, independent of grammatical information.[2] The phonological motivation for the rule is expressed by the featural characterizations of the vowel alternation relationships (see the vowel shift rule below).

To express the relationship between the members of the surface vowel pairs, Chomsky and Halle propose to postulate a unitary "abstract" vowel as the underlying representation for each pair, with the tongue height of the underlying vowel specified like its Middle English ancester. These vowels are also specified as [+tense] in order to effect the diphthongization and vowel shift processes. Thus, /ī/ is posited for [ay-ɪ] in *divine-divinity*, /ē/ for [iy-ɛ] in *serene-serenity*, /ǣ/ for [ey-æ] in *sane-sanity*, /ū/ for [aw-ʌ] in *profound-profundity*, /ɔ̄/ for [ow-ɔ] in *verbose-verbosity*, and /ō/ for [uw-ɔ] in *lose-lost*. The Vowel Shift rule formulated below is applied to these underlying forms to change the tongue heights of the first members of each pair.[3]

---

[2] Cf. a similar argument for the French vowel nasalization as a phonological process in Tranel (1981, pp.6-7).

[3] Before the application of the VS Rule, a laxing rule changes the tense underlying vowels in the second members to lax vowels in appropriate environments. See section 2.2.2.

4

$$\begin{bmatrix}\gamma\text{back}\\ \gamma\text{round}\\ \text{V}\end{bmatrix} \rightarrow \left\{\begin{array}{ll} [-\alpha\text{high}] \,/\, \begin{bmatrix}\overline{}\\ \alpha\text{high}\\ -\text{low}\end{bmatrix} & \text{(a)}\\ \\ [-\beta\text{low}\,] \,/\, \begin{bmatrix}\overline{}\\ \beta\text{low}\\ -\text{high}\end{bmatrix} & \text{(b)}\end{array}\right\} \;/\; \left\{\begin{array}{ll} \begin{bmatrix}\overline{}\\ +\text{tense}\\ +\text{stress}\end{bmatrix} & \text{(i)}\\ \begin{bmatrix}\overline{}\\ +\text{F}\end{bmatrix} & \text{(ii)}\\ \begin{bmatrix}\overline{}\\ -\text{tense}\\ +\text{high}\\ +\text{back}\end{bmatrix} & \text{(iii)}\end{array}\right\}$$

According to SPE, this vowel shift rule is a two-part exchange rule. The braces that combine parts (a) and (b) indicate that these two parts are to be ordered *conjunctively* – (b) after (a). Part (a) converts an input high vowel ([+high]) into a mid vowel ([-high, -low]); and a mid vowel into a high vowel. Then part (b) takes over and changes the mid vowel, which is the output of part (a), into a low vowel ([+low]); at the same time, part (b) converts a low vowel into a mid vowel. Some other restrictions are also imposed on the segments undergoing the vowel shift rule. First, in all cases the segment should have feature specifications that agree in [back] and [round], as can be seen from the left-hand side of the arrow in the rule. So the postulated /ā/ in *father* ([+back, -round]) and /œ̄/ in *boy* ([-back, +round]) are exempted from the rule. Secondly, the segment must meet one of the three further feature specification requirements: it must be [+tense, +stress], as in the case of *divine* /divīn/; or it must have a [+F] feature, which is designated for some lexical items such as the [ɪ-æ] alternation in *sing-sang*; or it must be a lax /u/, so that the vowel in *reduction* can be changed into [o], later to become the desired [ʌ] by a rounding adjustment rule. The first of these requirements, that the segment must be tense and stressed, is the typical environment of the vowel shift rule. It is this part of the rule which accounts for the vowel shift alternations on p. 3. The environments specified by (ii) and (iii) of the rule will therefore largely be ignored in the rest of the thesis. (As a matter of fact, these latter environments are dropped in Halle's (1977) revision; see below.)

Some other contingent rules such as diphthongization, rounding and backness adjustment are also applied to obtain the desired surface forms. The following diagram shows the derivations of the tense vowels which undergo the VS Rule:

ī	ū	ē	ō	ǣ	ɔ̄	UNDERLYING REPRESENATAION
īy	ūw	ēy	ōw	ǣy	ɔ̄w	DIPHTHONGIZATION
ēy	ōw	īy	ūw	(N/A)	(N/A)	VOWEL SHIFT (a)
ǣy	ɔ̄w	(N/A)	(N/A)	ēy	ōw	VOWEL SHIFT (b)
āy	āw	(N/A)	(N/A)	(N/A)	(N/A)	ROUNDING AND BACKNESS ADJUSTMENT
āy	āw	īy	ūw	ēy	ōw	SURFACE FORM

In Halle (1977), the major revision made to the VS Rule was that the input to the rule was changed to [V, +tense]. In effect, the requirements were lifted that the vowel undergoing the rule must be stressed and must agree in backness and roundness. A direct consequence of this is that one can posit /ʌ̄/ as the underlying vowel for "U" in *reduce* and *reduction* and include the alternation [(y)uw-ʌ] in the system. Thus the [uw-ʌ] alternation has replaced [uw-ɔ] in this version of the VS Rule.[4]

Besides this modification, Halle also dropped the eligibility of segments with [+F] and [-tense, +high, +back] features, and banned them from undergoing this rule. The rule has thus become:[5]

$$[+\text{tense}] \rightarrow \left\{ \begin{array}{l} [-\alpha\text{high}] \ / \ \begin{bmatrix} \overline{\quad\quad} \\ \alpha\text{high} \\ -\text{low} \end{bmatrix} \\ \\ [-\beta\text{low}\,] \ / \ \begin{bmatrix} \overline{\quad\quad} \\ \beta\text{low} \\ -\text{high} \end{bmatrix} \end{array} \right\}$$

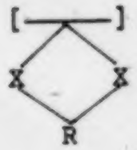
In the 1985 revision of the rule, Halle and Mohanan adopted the models of "lexical phonology" (Mohanan, 1982) and "autosegmental phonology" (Halle and Vergnaud, 1980) and restated the VS Rule as follows:

---

[4] Halle (1977) claims that [uw-ʌ] was the alternation intended to be covered in SPE. As pointed out by Cena (1976), however, SPE was not very clear regarding this "sixth pair", and many linguists believe it is [uw-ɔ] (cf. W. Wang, 1968; Cena, 1976; McCawley, 1979; and Jaeger, 1980). SPE indeed tried to account for the [uw-ʌ] alternation as demonstrated in *reduce-reduction* (p.220), but the vowel that was shifted was the "U" in *reduction*, that is, the short or "lax" variant (in the terminology of Chomsky and Halle). This can hardly constitute part of the system, as in the other five alternations it was the tense vowel that was shifted. Therefore I follow the above linguists in regarding the account of *lose-lost* (SPE, p.210) as the relevant one for SPE.

[5] This rule is identical to Rule (34) on page 187 of SPE, which is the first approach to the formulation of the VS Rule.

$$\begin{bmatrix}\alpha\text{high}\\ -\text{low}\end{bmatrix} \longrightarrow [-\alpha\text{high}] \qquad \begin{bmatrix}\beta\text{low}\\ -\text{high}\end{bmatrix} \longrightarrow [-\beta\text{low}] \quad /$$



Where R=Rime, and the two X's represent a long segment. Though the environment for the rule to take effect has changed from [+tense] (Halle, 1977) to a long vowel, it makes no difference for the purpose of the present study because this revision did not result in a change in the list of vowel pairs formally related by the rule.

However, in the 1985 paper, Halle and Mohanan explicitly proposed to include the [ɔy-ʌ] alternation (as in *destroy-destruction*) as part of the vowel shift phenomenon by positing /ü/ or /u/ (rather than /œ̄/ as in SPE) as the underlying representation for [ɔy].[4] But it seems to me that the theoretical manipulations of this kind are quite arbitrary, as can be seen from the following quotes when postulating the underlying forms for [ɔy] in different periods: "The vowel of phonetic [ɔ̄y] is low and round; therefore, if we are to avoid adding new rules to the grammar, we *must* take the underlying vowel V* to be *low* and round as well" (SPE, p.192); "Since the nucleus in these diphthongs [of *joint, point, noise*] is a low vowel on the surface, it *must* derive from an underlying long *high* vowel" (Halle and Mohanan, 1985, p.102; italics in both quotes added). Whether to assign [+high] or [+low] to the underlying form thus seems to have been based on the decision to include [ɔy] in the Vowel Shift Rule, and I have not found any independent reason for the decision.

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[4] Halle and Mohanan did not decide whether to choose /u/ or /ü/ as the underlying vowel, so it is not quite clear in their account how the surface forms [ɔy] and [ʌ] are actually to be derived. For a discussion of the underlying vowel for [ɔy], see Fidelholtz and Browne (1974). Halle (1977) also mentioned other possible treatments of [ɔy], but was not clear which vowel for [ɔy] to be paired with.

Summarizing, we can see that the orthodox theory of the Vowel Shift Rule has undergone two stages of change since 1968. In Halle's 1977 paper, the requirement that the input vowel to the VS Rule has to agree in backness and roundness was lifted. This resulted in the postulation of /ʌ̄/ for the stressed vowel in *reduce*, and the inclusion of the [uw-ʌ] alternation in the system, while the [uw-ɔ] alternation was excluded. In the 1985 version, the rule was extended to include the [ɔy-ʌ] alternation. The alternations that the various formulations of the VS Rule tried to account for can thus be recapitulated as follows, with the first five alternations common to all three versions of the rule:

[ay-ɪ]	*divine-divinity*
[iy-ɛ]	*serene-serenity*
[ey-æ]	*sane-sanity*
[aw-ʌ]	*profound-profundity*
[ow-ɔ]	*verbose-verbosity*
[uw-ɔ] (1968)	*lose-lost*
[uw-ʌ] (1977,1985)	*reduce-reduction*
[ɔy-ʌ] (1985)	*destroy-destruction*

1.2 On the Psychological Reality of Linguistic Rules

From the above explication of the vowel shift rule, we find there are several important claims associated with these rule formulations by orthodox generative phonologists. Of special interest here are the postulation of unitary "abstract" segments to represent the relatedness of the vowel pairs; the treatment of the phenomenon as a completely general and phonologically definable process; and the use of phonological features to express the operations behind the phenomenon. Since the generative phonologists ascribe psychological reality to formal linguistic constructs, the psychological content and validity of these claims ought to be examined.[7]

It has been shown that the metatheoretical principle of "formal simplicity" underlies the three claims above (Derwing, 1973, pp.135ff). But "formal simplicity" does not necessarily entail "psychological plausibility". It can be argued that the variation between [s] and [z] can be represented by an abstract morphophoneme /z/; that this phonological variation cuts across morphological classes and should be a purely phonological process; and that such variation is best characterized as a featural relationship (Derwing and Baker, 1979). But these arguments are not automatically applicable to other phonological phenomena, unless they are shown to involve the same type of phonological process. It is well known that the traditional generative phonologists have employed such arbitrary formal devices as extrinsic rule ordering, morphological information in the structural description of rules, diacritic features, diacritic use of phonological features, and rule features, all to make the phonological rules appear exceptionless (M. Wang, 1974, pp.48-69). Thus no distinction needs to be made among phonological rules in terms of generality or transparency. But this kind of homogeneous treatment of different phonological processes is soon found to be inadequate. Many ("concrete minded") phonologists argue that distinctions must be made between completely automatic (hence fully productive) phonological processes, and non-automatic (less productive) ones.[1] Generally speaking, the former type of rules define phonotactic surface constraints and are exceptionless. The psychological reality of such rules can usually be demonstrated by their productivity in psycholinguistic experiments. But the reality of the latter type is more difficult to ascertain. The vowel shift phenomenon is an example. Because there are many surface exceptions to this rule, its productivity is not directly observable. Thus some controversies over the rule are centered on whether one can attribute psychological reality to it. Chomsky and Halle clearly take the positive attitude,[1] but Maher (1969) argues that the rule is only a historical vestige and has no psychological content. Since the controversy is about the psychological status of the rule, the dispute can only be settled by considering empirical psychological evidence. Therefore, the first empirical question to be asked is about the "content" of the phenomenon: whether any kind of psychological reality can be demonstrated at all. As will be shown (in Chapter 2), evidence from various experimental studies does reveal some limited productivity of these vowel shift alternations. In performing various tasks, for example, the various experimental subjects tended to associate [æ] with [ey], [ɪ] with [ay], and so on. But overwhelming evidence also shows that this association is different in kind from that between English plurals [s] and [z] mentioned above. In this thesis, we will recognize this fact and move on to the question how the vowel alternations can be more realistically characterized.

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[7] We will not be concerned with the psychological content of the "exchange rule", because the notion is dependent on a featural analysis. As it will become clear that a featural approach to the phenomenon is implausible, the notion of "exchange rule" has no psychological relevance.

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[1] Some of the important proposals for such distinctions are Krohn's (1972b) major vs. minor rules; Kiparsky's (1973) transparent vs. opaque rules; Stampe's (1973) processes vs. rules; M. Wang's (1974) last vs. non-last rules; Hooper's (1976) phonetically conditioned rules vs. via-rules; Linell's (1979) phonotactic vs. morphophonological rules. See M. Wang (1974) for a discussion of some of these distinctions, which are all roughly comparable, though the rule forms and their theoretical implications can be quite different. Some linguists also propose a finer distinction between rules which are morpho-syntactically conditioned and those which are extremely idiosyncratic, e.g., Hooper's morphophonemic rules vs. via-rules. It will be shown that the vowel shift phenomenon has only limited productivity, and is largely dispensable (see Chapter 4). In this respect it resembles Hooper's via-rules, and by definition does not constitute anything like the "core" of Modern English phonology.

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[1] Halle (1977, p.613): "It was one of the major claims of SPE that this historical process [the Vowel Shift], which is first attested in Southern British dialects in the early sixteenth century, is an active component of the majority of dialects that are spoken today."

The first question about the nature of this limited productivity is whether the vowel alternation relationship is realized by native speakers in terms of phonological features. As we have shown, the featural relationship is assumed by the orthodox generative phonologists. This is because they have *a priori* accepted the correctness of the notion of "analysis into features" on the basis that it is "formally simpler". This formal claim should also be empirically tested.

A corollary of "analysis into features" is the question of "abstract segment". It has been assumed by the orthodox transformational-generativists that the relationships observed in linguistic forms are attributable to their common underlying forms, such as the /z/ in English plurals, and the surface variants are "derived" in a "generative" fashion. The strongest psychological support available for such a claim is that native spekers feel, for example, that the "s"'s in *cats* and *dogs* are the "same sound". Of course the empirical question that concerns us in this case is whether native speakers will also feel, for example, that the "i"'s in *divine* and *divinity* are the "same sound". If it cannot be shown that [ay] and [ɪ] are the same sound in some sense, then the postulation of an abstract /ī/ for both vowels has quite dubious empirical content.

It is the purpose of this thesis to achieve a clearer understanding of the vowel shift phenomenon through the consideration of the above formulated questions in the light of experimental evidence. After all, the English vowel shift phenomenon is one of the most studied phonological issues within the framework of generative phonology, and, if only for this reason, its psychological implications deserve our most serious attention.

1.3 Terminology

Some terminological matters must be clarified at this point. According to SPE, the vowels that are derived from the vowel shift rule are the "tense" vowels. While it is still not clear whether the vowels are related in a "shifted" fashion, this thesis follows the traditional morphological terminology of "base" and "derived". That is, a "base vowel" is the vowel used in the base form (root), for example, the [ay] in *divine*; a "derived vowel" is a vowel used in the derived form, as the [ɪ] in *divinity*. Therefore we can say [ɪ] is derived from [ay], but only in the morpho-phonological sense.

Although the vowel shift alternations (VS below) are the major concern, we also consider some other possible alternation patterns in this thesis. These patterns, with their abbreviations, are explained and illustrated below:

1. Vowel Shift Pattern (VS): a vowel alternation which is the result of the vowel shift rule (cf. the examples on

p. 9).

2. No Vowel Shift Pattern (NVS): an alternation between a tense and a lax vowel, but without a change in tongue height (e.g., *retain-retention*; *genteel-gentility*).
3. Anti Vowel Shift Pattern (AVS): a vowel alternation arrived at by reversing the sequence of the shift in the vowel shift rule (i.e., starting with low and mid vowels before going to mid and high vowels); or, in the SPE account, by reapplying the VS rule to the output of the VS rule itself – in other words, double application of the VS rule (see SPE, p.20, for the account of *clear-clarity*; other examples are *peace-pacify* and *equate-equivalent*).
4. Backward Vowel Shift Pattern (BVS): a vowel alternation exhibiting all the changes resulting from the vowel shift rule, plus a change in the feature [±back] (e.g., *strike-struck*; *foul-filth*).
5. Backward No Vowel Shift (BNVS): a vowel alternation exhibiting all of the no vowel shift (NVS) changes, plus a change in the feature [±back] (e.g., *hold-held*; *cow-calf*).
6. Backward Anti Vowel Shift (BAVS): a vowel alternation exhibiting all of the anti vowel shift (AVS) changes, plus a change in the feature [±back] (e.g., *gold-gilded*; *came-come*).
7. Changed to Tense Pattern (CT): a vowel alternation involving a change from one tense vowel into another

tense vowel (e.g., *mouse-mice; food-feed*).

8. No Change Pattern (NC): no vowel alternation, i.e., the vowels in both members of a related word pair are the same (e.g., *obese-obesity; nude-nudity*).

The diagram below, from McCawley (1979), summarizes these relations:[10]

	VS	NVS	AVS	BVS	BNVS	BAVS
ay	ɪ	æ	ɛ	ʌ	ɔ	ɔ
iy	ɛ	ɪ	æ	ɔ	ʌ	ɔ
ey	æ	ɛ	ɪ	ɔ	ɔ	ʌ
aw	ʌ	ɔ	ɔ	ɪ	æ	ɛ
uw	ɔ	ʌ	ɔ	ɛ	ɪ	æ
ow	ɔ	ɔ	ʌ	æ	ɛ	ɪ

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[10] Obviously, this diagram follows the 1968 version of the VS rule.

Chapter 2

Review of Related Experimental Studies

This chapter consists of two parts. The first part contains reviews of seven experimental studies on the psychological reality of the vowel shift rule. The second part contains reviews of two experimental studies on the word structures that provide the environments for the vowel shift rule (or laxing rule) to take place. Then the results and implications are summarized and discussed in a separate section.

2.1 Review of Experimental Studies on the Psychological Reality of Vowel Alternations

Since the 1970's quite a few experiments have been done testing the psychological reality of the Vowel Shift Rule (VSR) proposed by Chomsky and Halle (1968). Basically the experiments were all concerned with whether the rule had psychological content. These experiments are generally of four types: Production tests, Preference tests, Recall tests, and Concept Formation tests. In the production tests, the subjects were given a base form containing a tense vowel, such as *maze* (real word) or *verane* (nonsense word), and was asked to add suffixes such as *-ic* or *-ity* to the root. These suffixes, according to SPE, provided laxing environments which would cause substantial vowel changes as depicted in section 1.1. The subjects were observed on whether they changed the vowel quality as predicted.

In the preference tests, subjects were given a base form as above, and they was given two derived forms to choose from. The expectation was, since these derived forms all provide proper laxing environments, the choices should tend toward the ones predicted by the vowel shift rule.

In the recall tests, subjects were taught both the nonsense base forms and their derived forms containing a lax vowel. For the same tense vowel, some base forms had derived forms of the VS patterns, while others had other patterns. Then the subjects were tested on how well they remembered the derived forms when cued with base forms. The expectations were that subjects would tend to remember the derived forms with VS patterns better, and the errors would tend to drift toward the VS patterns.

In the concept formation tests, subjects were taught to respond positively to the word pairs containing VS patterns, and negatively to others. After this concept had been formed, subjects were then observed on how they reacted to other patterns not included in the training sets. The expectations were that new patterns which conformed to the general VS rule would be responded to just as positively as those used in the training session.

In all these experiments, those which allowed the possibility of no change (NC) patterns, i.e. the production tests and one of the preference tests (Armbruster, 1978), have failed to bear out the expectations. But in other experiments evidence seemed to indicate that the native speakers do possess knowledge of vowel alternations to some degree. In the following sections, I will discuss these four types of experiments in the order indicated.

2.1.1 Production Tests

2.1.1.1 Ohala

Ohala (1974) told his subjects that he was preparing an extrapolated dictionary of English. In the experiment, subjects were asked to help him with the job by adding suffixes to the existing word stems. The subjects were to pronounce the newly invented word, tell its meaning, and tell if they would be likely to use it. Ohala asked the subjects first to add *-tion* to the words *obtain* and *pertain*, and later he asked them to add *-atory* to the same words. In the first case subjects were prompted with the pair *detain-detention*, while in the second case they were prompted with the pair *explain-explanatory*. The results for *obtain* are shown in Table 2.1. The vowels listed in the table are the vowels used by the subjects for the second syllable when the suffixes were added. As is shown, of the 26 subjects, 18 changed the vowel [ey] to [ɛ] when adding *-ion*, and 8 did not change the vowel quality. When *-atory* was added to the stem, 16 subjects retained the original vowel, while 10 subjects changed the vowel to [æ]. Of these 10 subjects, 9 were a subgroup of the 18 in the *-ion* task who responded with [ɛ]. Since subjects responded differently in the two

Table 2.1 Results of Ohala's Experiment Adding Suffixes to *obtain*

	Response		
stimulus	ɛ	ey	æ
obtain + ion	18	8	0
obtain + atory	0	16	10

situations, Ohala concluded that their responses could not have derived from the same, single underlying form. Rather, he suggests that "the particular form of the derivations... does depend on other words or pairs of words in the lexicon of the speaker" (1974, p.372). In other words, the subjects used the strategy of "analogy" in modeling their responses on the prompted patterns.

Ohala's experiment is not really persuasive in attempting to support or refute Chomsky and Halle's proposals. For one thing, the words used in the experiment, *obtain*, *pertain*, *detain*, *explain*, all end in *-ain*, and the way the words were prompted provided a very transparent environment for analogy. Since analogy is a convenient strategy to employ, and there is no doubt that language users do make use of it, it is not surprising that Ohala should get the result that he did. However, there is one interesting further point to be noted. Since 18 subjects changed [ey] to [ɛ] in *-ion* task and only 10 subjects changed [ey] to [æ] in *-atory* task, it seems as though the subjects were more prone to vowel changes of the NVS fashion than to the VS type of changes. In some restricted sense, therefore, the results of the experiment disconfirmed Chomsky and Halle's theory about vowel alternations.

2.1.1.2 Steinberg and Krohn

Steinberg and Krohn (1975) assigned their subjects to one of two experimental conditions. In the first condition, 26 real English words were used as test items to elicit corresponding forms with various endings. These endings include *-ic*, *-ical*, *-ity*, *-ify*, and *-ish*. With the exception of *-ish*, all other suffixes should invoke vowel quality changes in the original word stem, according to the formulation of SPE. For each test item, a passage was read to the subject, and the subject had to choose between two suffixes to the test word to fit in the passage, and the subject was to say aloud the newly formed word which he thought would fit into the frame. The assumption was that if the vowel shift rule was psychologically real, then the responses given by the subject would show vowel changes as predicted by SPE in proper environments. The second condition was similar to the first except that the stimuli were presented to the subjects in written form. The results are summarized in Table 2.2. In this table, Steinberg and Krohn showed that 90% of the responses made by the subjects involved no change in the vowel quality, contrary to the expectations of the rule. A total of only 3.5% of the responses demonstrated the alternations predicted by the

Table 2.2. Proportions of Responses according to Types in Steinberg and Krohn's Study

Condition	No. S's	Changes on Vowels		
		VS	Other	No Change
I (oral stim.)	24	.03	.08	.90
II (written stim.)	16	.05	.05	.90

vowel shift rule. Steinberg and Krohn concluded from these results that vowel shift rule can not be a general rule, and that the associated claim that the English orthography is nearly optimal is not valid.

Comparing the results of both experimental conditions in this study we find that while the proportions for the "no-change" responses were virtually identical, those for the other two types of responses were different. Whether the difference was statistically significant is not indicated, but it seems that since the second experiment was presented with written stimuli, orthographical influence might have contributed to part of the difference. An examination into the responses made to each alternation pattern (conditions I and II combined) showed that 20 out of the total 27 VS responses were of the [ay-ɪ] type. This demonstrates the inequality in the strengths of different vowel alternations. Comparing the VS responses with other tense-lax responses, we find that there were 29 [iy-ɪ] responses, 4 [ay-æ], 2 [ay-ɛ], and 3 [ey-ɪ]. In these four patterns, the first two are the NVS patterns, and the last two are the AVS patterns. Notice that the number of [iy-ɪ] responses alone is greater than the total of VS responses (27). Thus it seems that if the vowel alternation phenomenon has any reality, the contribution of the VS rule is limited almost entirely to the [ay-ɪ] pattern.

A question was raised by Kiparsky (1975) about the experimental design of this study. He faulted Steinberg and Krohn's use of Germanic stems in the experiment.[1] The criticism is valid to the extent that it has been shown by Randall (1980) that native speakers of English do realize the difference in word origins (see section 2.2.1). Nevertheless this also shows that even though the reality of the vowel shift rule is a question, we can be certain that the rule can not be *general* in the sense that it underlies all of English phonology. In other words, even granting the reality of the vowel shift rule, it can only apply to a particular set of English lexical items, rather than to the whole lexicon.

2.1.1.3 Myerson

In Myerson's study (1976a,b), she used 72 students as subjects, 18 each from the third, sixth, ninth and twelfth grades. She conducted three experiments to test the psychological reality of five phonological patterns:

1. Patalization before *-ion* as in *relate-relation*.

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[1] The vowel alternations, according to Chomsky and Halle, "are found primarily, but not solely, in the subpart of the vocabulary that is of Romance origin" (*SPE*, p.178).

2. Vowel shift before *-ity* as in *sane-sanity*. (Only the [ey-æ] alternation was tested in this environment.)
3. Vowel shift before *-ical* as in *meter-metrical*. (Only the [iy-ɛ] alternation was tested in this environment.)
4. Stress shift before *-ity* as in *moral-morality*.
5. Stress shift before *-ical* as in *history-historical*.

The three experiments Myerson did involved a production test, a preference test, and a recall test, all conducted orally. Since the vowel shift alternations are the point of interest here, we will concentrate on only the second and third patterns above. But since the other patterns have some bearing on her conclusion about the relevance that orthography has on the vowel shift, we will return to these other patterns in our later discussion of her third experiment, the recall test.

In Myerson's production test, the nonsense words *derave* ([dəreyv]), *glane* ([gleyn]), *glete* ([gliyt]), and *beleter* ([bəliytɚ]) were used. Subjects were first taught to associate specific meanings to these words, with the help of definitions and short illustrative passages. Then the subjects were asked to add *-ity* to the first two words and *-ical* to the last two. The subjects' VS responses are reported in proportions in Table 2.3. The overall VS responses were only 5%, quite similar to the results in Steinberg and Krohn's study. Needless to say, the expectation for the VS rule to be productive failed in this experiment, as well. The fact that Myerson explicitly

Table 2.3. Proportions of VS Responses in Myerson's Production Test

	Grade				
Alternation	3	6	9	12	Overall
[ey-æ]	.08	.03	.08	.11	.08
[iy-ɛ]	.00	.08	.00	.03	.03
Overall	.04	.06	.04	.07	.05

followed Kiparsky's suggestion of patterning her nonsense words on the proper word class/origin categories, and still found no productivity is evidence that the word types in the Ohala and Steinberg/Krohn studies were not the cause of the lack of productivity (cf. Jaeger, 1980, p.229).

2.1.1.4 Armbruster

Armbruster (1978) conducted three production tests on the psychological reality of the vowel shift rule. They are discussed separately as follows:

Experiment I

The subjects in this experiment were 42 university students. The experiment comprised eight sessions with a one-week break between each session. The first two sessions were the learning phase in which the subjects learned six nonsense words by listening to a taped passage of a real news report in which these six nonsense words replaced six of the real adjectives. The six nonsense words were [briyn, zeyt, θayb, čuwp, gowk, fæwd]. From the third session on the subject was assigned to one of two test conditions. In

Table 2.4. Proportions of VS Responses in Armbruster's Experiment I (Oral Stimuli)

	Week						
Group	3	4	5	6	7	8	Overall
I (alt. prompts)	.14	.10	.15	.14	.20	.21	.16
II (nonalt. prompts)	.02	.03	.03	.06	.04	.05	.04

both conditions, the subjects were asked to form nouns out of these six adjectives by adding *-ity* to the end. In Condition I the subject was prompted with real examples exhibiting VS patterns (*divine-divinity, obscene-obscenity, profound-profundity, sane-sanity, verbose-verbosity*), while in Condition II, the subject was prompted with real examples which retain vowel quality before *-ity* (*obese-obesity, nude-nudity, nice-nicety, immune-immunity, crude-crudity*). In these test sessions the subject was asked to make sentences containing the adjectives and the derived noun forms. The results of the experiment, summarized in Table 2.4, showed that the subjects in Condition I who were given VS patterns as cues were more likely to change vowels according to VS patterns than the subjects in Condition II; they also showed that a general propensity to alternate vowels according to VS patterns increased over the sessions. The trend of increase was significant. Nevertheless, the overall VS productivity rate was still low, as in the previous experiments.

Experiment II

The second experiment by Armbruster was to test the influence of the spelling of the stimulus adjectives on the propensity to make productive vowel alternations. It took four sessions to complete the experiment, with a one-week break between each session. Forty-one university students took part in this experiment. Each subject was taught four nonsense words, but this time the stimluli were given in written form. The subject was assigned to one of two experimental conditions. In both conditions, the subjects were asked to read a one-page story in which several real words were replaced by nonsense words. In Condition I, the nonsense words were written with the alternating spellings *brene, zate, thibe, goke*, and in Condition II, the nonsense words were written with the non-alternating spellings *breen, zait, thybe, goak.*[2] These nonsense words were pointed out to the subjects after they finished reading the story, and were supplied with meanings. The first two sessions were the learning sessions. In the third and fourth sessions the subjects were asked to make noun forms by adding *-ity* to the end of the four words. This time the prompts used in both conditions were those real alternating pairs used in Condition I of Experiment I (*divine-divinity*, etc.). The results of this experiment, summarized in Table 2.5, showed

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[2] Strictly speaking, the spelling *y* should not have been included here, as it does exhibit occasional VS alternations, such as *type-typify* (or *typical*); *tyrant-tyranny*.

Table 2.5 Proportions of VS Responses in Armbruster's Experiment II (Written Stimuli).

Group	Week 3	Week 4	Overall
I (alt. spell.)	.39	.38	.39
II (nonalt. spell.)	.15	.14	.15

that the subjects in Condition I, i.e., those who read the story containing the alternating spellings of the nonsense words, were much more likely to produce vowel alternations than the subjects in Condition II. Thus it seems that the way the words were spelled did have a significant effect on their VS activities.

A further examination of the results shows that subjects in Condition I of Experiment II scored over 38% in both test sessions, while those in Condition I of Experiment I using the same prompts never advanced beyond 21%. This positively demonstrates that spelling did have influence on subjects' propensity to change vowels. But, on the other hand, if we look at the performance of Condition II in Experiment II, the negative force of spelling over vowel alternation was not so obvious. The spelling stimuli for Condition II were designed in such a way as to prohibit vowel change, yet in sessions 3 and 4, the subjects scored 15% and 14% respectively. The figures are thus not too different from the initial performance of the Group I subjects in Experiment I (14% and 10% respectively for sessions 3 and 4). What this difference means is difficult to assess and explain, but I suspect that because the prompts of Condition II in Experiment II were real alternating pairs, the subject might have tried to vary the vowel, regardless of the spelling, thus reducing the orthographic effect.

Experiment III

The third experiment was a test of whether the quality of the consonant following the tense vowel contributed to the subjects' tendency to lax the vowel. The stimuli were given orally, and the subjects were taught the new words in the manner described in Experiment I. As in the previous two experiments, two test conditions were set up. The stimuli used in Condition I were [briyn, spleyn, glayn], and those used in Condition II were [briyt, spleyt, glayt]. The stimuli in both conditions differed only in the last consonant. Scores were taken in the third and fourth sessions. As shown in the results summarized in Table 2.6, subjects in Condition I produced significantly more VS responses than the subjects in Condition II (α=.05). This indicates that the vowels before [n] are more prone to be laxed than those before [t].[3]

The general conclusions Armbruster drew from the results of these experiments are that "vowel shift is not psychologically real, that only the structure specified by

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[3] Armbruster considered all changes to lax vowels as correct answers, including changes from [aw] to [a], which was not a VS response.

Table 2.6 Proportions of VS Responses in Armbruster's Experiment III (-*n* and -*t* Endings).

	Week		
Group	3	4	Total
I (-*n*)	.24	.29	.26
II (-*t*)	.09	.12	.10

the output of the laxing rule is in a sense psychologically real, and that morpheme structure preferences, spelling conventions, and references to learned graphemic representations form the mechanism by which those subjects who do change vowels in these experiments do so" (p.129).[4]

While these experiments are interesting and revealing, there are two questions about the generality of the results to be asked. The first is how representative the reported results are across subjects. For the results obtained from Group I in Experiment I (Table 2.4), for example, the overall VS responses was 16%. An ANOVA test showed that the subject effect had an $F(20,735)$ value of 16.45, which is significant ($p<.05$). Looking at his raw data we find that three subjects scored no predicted answers over the six weeks, and five scored only one; on the other hand, one subject scored 27 out of the possible 36, and another scored 26. This indicates that the little productivity demonstrated in the results is not a proper measure for each individual subject. There were obviously subject groups who employed different strategies or had different degrees of awareness of the vowel alternation phenomenon. By grouping subject performances, much information about the possible vowel alternation relations was lost.

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[4] For his experiments on the laxing rule and morpheme structure preferences, see section 2.2.2.

The second generality question to be asked is the variability of responses across items. The subject who scored 27 mentioned above scored none in the [aw-ʌ] alternation. And most subjects who scored anything at all scored [iy-ɛ] most. As a matter of fact, the [iy-ɛ] alternation accounted for almost half (44%) of the correct responses. This inequality in the productivity of alternation patterns raises a very serious question about Chomsky and Halle's conception of vowel shift as a unitary phenomenon to be described in terms of a single general rule.

2.1.2 Preference Tests

2.1.2.1 Myerson

Myerson's second experiment in her 1976 study was a preference-choice test. The same 72 subjects as in the first experiment took part in this experiment. Four nonsense words were used in the test: *lemave* ([ləmeyv]), *skane* ([skeyn]), *reveter* ([rəviytɚ]), *gemeet* ([gəmiyt]). Each nonsense word was associated with two derived forms, one with a VS pattern, the other with an NVS pattern. The derived forms of the first two nonsense words (with [ey]'s

Table 2.7 Proportions of VSR Responses in Myerson's Preference Test

	Grade				
Alternation	3	6	9	12	Overall
[ey-æ]	.56	.67	.64	.61	.62
[iy-ɛ]	.61	.64	.58	.69	.63
Overall	.58	.65	.61	.65	.63

in the base form) had *-ity* endings, and those of the last two words (with [iy]'s in the base form) had *-ical* endings. As shown in Table 2.7, more than half of the time (63%), the subjects chose the forms with VS patterns. This seems to suggest that native speakers have knowledge of the VS alternations, at least in the sense that they rather consistently prefer them to NVS alternations.

The results of this study conflicts with those of Ohala's (1974) production test. But it is hard to assess the difference of the results. Ohala's test used real words, but did not provide the contexts in which the words were to be used. In Myerson's experiment, derived nonsense forms were provided to the subject in the context of sentences. It is not clear whether the differences in test conditions could have caused the differences in the realization of the vowel alternations.

2.1.2.2 Armbruster

In the first experiment of Armbruster's production test (section 2.1.1.4), he did a preference test during the fifth through the seventh week in addition to the sentence formation task. Remember that by this time the subject had already acquird the meanings of the six adjectives ([briyn, zeyt, θayb, čuwp, gowk, fæwd]) in the learning sessions, and had gone through two test sessions already. In this test the subjects were asked to choose between two *-ity* forms corresponding to each of the six adjective bases. One of the *-ity* variants followed the VS pattern, and the other retained the tense vowel (the NC pattern). In the three preference tests (one in each of the sessions from week 5 to 7), the subjects chose the lax forms only 17% of the time. This indicates a great preference for no change patterns over vowel shift patterns.

2.1.3 Recall Tests

2.1.3.1 Myerson

The third experiment Myerson performed was a word recall test. The subjects were the same 72 students as in the first two experiments. In the learning session, the subject was taught four pairs of words in context. The base words in each pair were: *verane* ([vəreyn]), *trave* ([treyv]), *dereter* ([dəriytɚ]), *megeet* ([məgiyt]). The subject was taught their derived forms in one of two versions. In Version A, *verane* was associated with *veranity* ([vərænəti]), *trave* with *trevity* ([trɛvəti]), *dereter* with *deretrical* ([dərɛtrɪkəl]), and *megeet* with *megitical* ([məgɪtɪkəl]). In Version B, the base forms were associated with *verenity*

Table 2.8 Results of Myerson's Recall Test, Third Test Session Only.

	Grade				
	3	6	9	12	Overall
Alternation	Proportions of Correct Responses				
VS	.31	.56	.69	.72	.57
NVS	.14	.14	.44	.36	.27
Error Type	Proportions of Errors				
NVS→VS	.31	.33	.33	.36	.33
VSR→Lax	.03	.03	.08	.03	.04

([vərɛnəti]), *travity* ([trævəti]), *deritrical* ([dərɪtrɪkəl]), *megetical* ([məgɛtɪkəl]), respectively. Half of the subjects were taught Version A and half were taught Version B. As in the production test, these words were taught in context, except that both base forms and derived forms were given. Three test sessions were held on one-day, one-week and six-week intervals after the learning session to test the subjects on their ability to remember the ten derived words. The results for the third session, which according to Myerson was the most successful, are summarized in Table 2.8. As can be seen from this table, there is an increasing trend of success with age, and the percent correct of responses following the VS pattern is more than double that of no shift alternation (57% vs. 27%). An even more significant difference is found in incorrect answers. While the errors toward VS pattern were about 33% of total answers, the drift toward no shift pattern was only a trivial 4%. This strongly suggests that rules of the VSR kind were functional in these responses. Therefore Myerson concluded that the study "has provided evidence for the psychological reality of certain of N. Chomsky and M. Halle's phonological rules in *Sound Pattern of English*" (1976a, p. 220).

However, we should observe that the positive results of VS responses in Myerson's recall test and preference test only showed up when two lax varients of the tense vowel were compared. In other words, the VS alternations manifested themselves only when subjects had first been shown that the expected response involved a vowel that was different from the one in the base form. Even in this situation, Myerson's data (1976a, p.117) showed that her subjects made 77 errors (27%) of the no-change type in the third session of the recall test. The conclusion one can properly draw is only that the VS pattern was more preferrable or better remembered than the NVS pattern. This fact is significant in itself, but to claim from this that the VS rule in SPE is real is a *non sequitur*. Myerson did try to provide some justification for the "phonological" solution of the vowel shift phenomenon by relating the problem to the results of the test on the stress shift rules, but her arguments seem to me quite unconvincing. Let us take a look at the evidence she tries to provide for the argument.

As we have mentioned in section 2.1.1.3, in addition to the vowel shift patterns Myerson also tested palatalization (*-ion*) and stress shift (*-ity* and *-ical*) rules. Besides trying to show the psychological evidence for these rules, Myerson wanted to determine whether the child's acquisition of "inner knowledge" of these patterns is relatable to English orthography (1976b, p.380). Of the five sound patterns used in the study, three are encoded in the English writing system (i.e., the palatalization pattern and two vowel shift patterns), and two do not have visual representations (i.e., stress shift patterns; see section 2.1.1.3). Based on the results of the three experiments, she established a learnability hierarchy, from the easiest to the hardest, as follows (1976b, p.401):

1. Palatalization of dental before *-ion*.
2. Vowel shift before *-ity*.
3. Stress shift before *-ity* (implied stress shift before *-ical*).
4. Vowel shift before *-ical*.

Probably because the stress shift is between the vowel shift patterns in the hierarchy, Myerson argues that:

> Since the study showed that children acquire inner knowledge of word formation rules independent of whether or not the sound changes are encoded in the spelling system, it seems difficult to attribute children's inner knowledge of vowel shift *-ity* to the English spelling system if one can not attribute inner knowledge of stress shift to the same source. (1976b, p.401)

But this argument is only valid to the extent that the vowel shift rule is shown to be the same kind of phonological phenomenon as stress shift. As a matter of fact, the following quote from her (1976b) paper seems to have provided counter-evidence against her claim:

> With palatalization -ion, third graders did poorer on conscious judgment [i.e., the preference test] than on the recall test, but on the stress shift items the reverse was true, and on the two vowel shift items the third graders performed similarly on each test. The explanation of such differences lies in the fact that the children could solve the conscious judgment items using different strategies *depending on the sound pattern*. (1976b, p.399; italics added)

Thus it seems that the vowel shift and stress shift phenomena are different in kind and need not be attributed to the same source, and her conclusion about the psychological reality of VSR as a phonological rule does not follow from her results. (For similar arguments, see Jaeger, 1980, p.236.)

There is another problem associated with Myerson's study, as well, namely, she tested only the [ey-æ] and [iy-ɛ] alternations. She therefore provides no evidence on the question of whether her findings are generalizable to the other patterns. In other words, she merely assumed the generality of Chomsky and Halle's vowel shift rule (much as Berko did in her classic 1958 study of the rules for English pluralization; see Derwing, 1979). In her reasoning, since part of the rule was proved to have reality, she inferred that the entire rule was true. But this does not necessarily have to be the case. It is very possible that the language users have learned the vowel alternation patterns on an ad hoc basis, or that they have only realized a subset of the alternations captured by the rule. Whether either of these limitations hold cannot be determined from Myerson's experimental results, because in all three experiments she associated [ey-æ] alternation with the *-ity* suffix, and [iy-ɛ] alternation with the *-ical* suffix. In the production test and the recall test, the subjects in fact did better on [ey-æ] than on [iy-ɛ], but it is not clear whether the difference is due to the different strengths of the alternations, or to the different strengths of the laxing environments provided by the suffixes. Armbruster's (1978) experiment may provide some clue (see section 2.1.1.4). In his production task, he used the *-ity* suffix for all the alternations, with best performance on the [iy-ɛ] alternation. This seems to indicate that the two explanations for the differences in the behavior of the alternations are both possible. On the one hand, Armbruster's data suggest that there is an ad hoc character to the alternations because, even though the suffix variable was controlled, the alternations still showed different strengths. On the other hand, the weak behavior of the [iy-ɛ] alternation in Myerson's experiment might be the result of the *-ical* environment. Until these questions are clarified further, not much can be said about Chomsky and Halle's vowel shift rule itself.

2.1.3.2 Cena

Cena's study (1976,1978) employed a learning-memory paradigm in the experiment. Five tense vowels, [ay, iy, ey, aw, ow], were used in constructing 25 nonsense adjective bases with Romance prefixes. For each of the five adjective bases sharing the same tense vowel, a corresponding *-ity* noun form was constructed with the tense base vowel replaced by one of the five lax vowels, [ɪ, ɛ, æ, ʌ, ɔ]. Hence there were 25 adjective-noun pairs used in the test. The subjects were 20 university students. In the experiment, the subjects were taught to associate each adjective base with its nominal counterpart. After the learning phase, the subjects were tested on how well they remembered each pair. For each item, an adjective base was given, and the subjects were asked to respond with the corresponding nominal form which they had been taught. The procedure of learning and testing was repeated ten times. It was expected that alternations following the vowel shift rules would be the easiest to learn and the errors made would tend to follow the VS pattern. These predictions were generally borne out with the exception of the [aw-ʌ] pair. (See Table 2.9 for a summary of Cena's experiment.) As Cena observed, the study only tested the "substantial reality" of the vowel shift rule; no implication can be drawn on the "formal reality" of the rule. Thus he claimed that "the *substantive* basis of vowel alternation in English is psychologically real" (1976, p. 161). However, his study only showed that only *some* of the predicted alternations are real. As noted above, not all the predictions by the vowel shift rule of SPE were borne out, as the [aw-ʌ] alternation did not demonstrate

Table 2.9 Frequencies of Responses in Cena's Experiment (Italicized frequencies are response types expected by VSR)

A. Number of Correct Responses

		Required Responses				
		ɪ	ɛ	æ	ʌ	ɔ
Stimulus:	ay	*154*	92	70	83	131
	iy	75	*142*	113	48	53
	ey	99	45	*168*	92	103
	aw	64	84	77	*100*	135
	ow	45	54	81	100	*185*

B. Number of Errors

		Error Types				
		ɪ	ɛ	æ	ʌ	ɔ
Stimulus:	ay	*210*	92	72	24	29
	iy	166	*235*	21	82	19
	ey	69	63	*238*	32	58
	aw	70	78	40	*79*	205
	ow	55	64	20	35	*316*

predicted strength. As shown by the frequencies of correct responses and errors in Table 2.9, the [aw-ɔ] alternation was obviously more favored than the [aw-ʌ] alternation. McCawley (1979) noted the significance of the results of the [aw-ɔ] alternation in this study, and further pointed out that since English does not have any clear example of an [aw-ɔ] alternation the subjects could not have produced the responses on an analogical basis.[1] One possible explanation is that the subjects employed some kind of rule in performing the task, and the [aw-ɔ] alternation is the result of the extension of that rule to the case of [aw]. The Vowel Shift Rule is not a viable candidate to do this, however, as (in all three of its formulations noted in Chapter 1) the input and output vowels must always differ in terms of tongue height features.

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[1] Hanna and Hanna (1966) lists 406 words with [aw] vowel in various positions, among which I found only five which have possible related words with [ɔ] sound: *sound-sonic*, *astound-astonish*, *bound-bondage*, *noun-nominal*, *pronoun-pronominal*. Word pairs with [aw-ʌ] alternation are about double that number: *bound-bundle*, *abound-abundant*, *pronounce-pronunciation*, *profound-profundity*,

Using the coincidence distance matrix method described in Baker and Derwing (1982) to reanalyze Cena's data, there were no discernible subject groups except in the tenth trial, where three groups emerged quite distinctly. Examining the data, we found that there were essentially two strategy groups. One group, comprising five subjects, could be termed the "Correct Response" group, because they were characterized by 84% correct responses required by the test. The other strategy group could be called the "Rule Response" group, where subjects gave 40% VSR responses in front vowel series, and 66% NVS responses in the back series (i.e. [ɔ], the NVS variant for both [ow] and [aw]). The remaining ten subjects were more or less indeterminate, as no obvious response patterns can be found in their data. What is interesting to observe is that in the "Rule Response" group, *none* of the responses given to [aw] category was [ʌ], while [ʌ] was given at least one time in each of the other categories. This suggests that even the most tenacious

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[1] (cont'd) *south-southern, found-fundamental, announce-annunciate, renounce-renunciation, denounce-denunciation, foundation-funding.*

subjects who held on to the "rule" strategy did not regard the [aw-ʌ] alternation as part of the phenomenon.

2.1.4 Concept Formation Tests

2.1.4.1 Moskowitz

Moskowitz (1973) employed a concept formation paradigm to experiment on a group of 25 children ranging from 9 to 12 years. Each subject was assigned to one of three test conditions. The subjects were given nonsense words containing tense vowels and was asked to add *-ity* to the nonsense word. They were shown two examples of how the *-ity* was to be added. In the first test condition, the examples included changes in vowel quality following the VS patterns ([iy-ɛ], [ay-ɪ]); in the second condition, the examples included vowel changes of the NVS type ([iy-ɪ], [ey-ɛ]); in the third condition, the examples were anti vowel shift (AVS) type of alternations ([iy-æ], [ey-ɪ]). Each subject then went through a learning phase (Part A) in which 72 nonsense words were presented, and the subject was asked to supply the corresponding forms with the *-ity* ending. The correct responses were accepted, and the incorrect answers were rejected with correct answers provided by the experimenter. Then in Part B a third vowel alternation was introduced with six word pairs, which was [ey-æ] for Group I, [ay-æ] for Group II, and [ay-ɛ] for Group III. The task was the same as the first part and the responses were accepted or rejected as in Part A. In Part C, the subject was given 12 items containing four tense back vowels, [ōw, ǣw, ɔ̄w, ūw]. The subject was asked to say their corresponding *-ity* forms. Unlike Part A and Part B, the subject did not get feedback from the experimenter about the correctness of the responses.[4] The scores were taken depending on whether the subjects had learned the alternations to criterion (ten error-free trials) in Part A, and the number of correct answers given to Parts B and C.

The results of the experiment are summarized in Table 2.10. As can be observed, the subjects in Condition I (the VS pattern) did significantly better than those in the other two conditions. Everyone in this group learned to criterion in Part A, and the number of trials before reaching criterion was significantly lower; we can also infer from the results in Part B that the alternations were easily generalized to the third alternating pair. None of the subjects in Condition II learned to criterion, and only two learned to criterion in Condition III. The results clearly showed that the alternations in the front series following the vowel shift rules were easier to learn; they also showed that AVS alternations were easier to learn than the NVS

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[4] Moskowitz meant for these 12 items to show six alternation patterns, three of which were real pairs (e.g. in the VS group they were [ǣw-ʌ] *profound-profundity*, [ōw-ā] *verbose-verbosity*, [ōw-ə] *custodian-custody*) and three were derived by rules (e.g. in the VS group they were [ūw-ǒ], [ōw-ɔ̄], [ɔ̄w-ǔ]). But since the responses to these items were all acknowledged without the subject being told what the correct answers should have been, these "patterns" are only the expectations that the subjects should give if they were following the rule.

Table 2.10. Results of Moskowitz's Experiment

	Conditions		
	I VS	II NVS	III AVS
% Subjects learned to criterion in Part A	100	0	25
% Items correct in Part B	77	4	31

pairs (though the latter point is inconclusive in that the subjects' responses to Part B were quite inconsistent; for example, one subject on Condition III who learned to criterion in Part A missed every item in Part B, whereas another who did not learn to criterion in Part A scored every item correctly in Part B). No interesting results were obtained from Part C, as they were "equally bad for all three groups" (p.244): some subjects gave only front vowel responses, others responded with a stressed schwa.

Moskowitz concluded that "The source of these children's knowledge of vowel shift then is the spelling system of English" (p.249). She based this claim on the fact that children are usually taught the "long" and "short" varieties of the same vowel letter, and also that several subjects on Condition I asked questions such as "Oh, you just want me to make a long 'i' into a short 'i', right?" (p.247). Concerning the possible form the knowledge takes, she claimed that it is likely a reflection of its orthograpic source, and that "the *SPE* proposal about vowel shift bears no resemblance to the functional grammar of native speakers" (p.249).

While her experimental results are interesting, Moskowitz's conclusion that the alternations have their source in the spelling system in English does not necessarily follow from her experiment. For the two reasons cited above, that of children's learning pronunciation of letters and that of some subjects' comments on the task, the phonological hypothesis does not have to conflict with the first, and the second only shows that some subjects have conscious awareness how the vowel alternations are reflected in spelling. Such conscious awareness does not rule out the possibility that the subjects have some other kind of unconscious rules that might also affect their performances.

Kiparsky and Menn (1977) also disagreed with Moskowitz on this point. They stipulated that

> The vowel shift *pattern* itself, whose knowledge was at issue, is of course contained in quite basic vocabulary, notably in the inflectional morphology of verbs *hide-hid*, *bite-bit*, *feed-fed*, *keep-kept*, and so on. It is therefore not so surprising that children know it, and there is certainly no need to invoke spelling as a necessary source of this knowledge. Indeed, the poor performance on the back vowels is evidence against this. (p.65)

But the question whether the subjects responded on the basis of phonological rules or spelling rules is not so easily settled, for although Kiparsky and Menn may be right in arguing that the poor performance on the back vowels is evidence against spelling rules, the evidence does not particularly favor the phonological rule, either. It is possible that only the alternations in the front vowel series are productive for speakers. It is also possible that because the spellings for back vowels are more heterogeneous, they are more difficult to handle, at least for the nine to twelve year olds. Further empirical evidence is again called for to clarify these issues.

2.1.4.2 Jaeger

Jaeger (1980, 1984) conducted a concept-formation experiment to test whether the subject's performance of vowel alternation is based on their knowledge of a Vowel Shift Rule (VSR) or a Spelling Rule (SR). The subjects listened to the stimuli of real English word pairs from a tape recorder. Half of the stimuli contained alternations common to both the VSR and SR patterns. These alternations were [ey-æ] (*inflame-inflammatory*), [iy-ɛ] (*deceive-deception*), [ay-ɪ] (*derive-derivative*), and [ow-a] (or [ow-ɔ]) (*compose-composite*), and constituted the positive tokens. The other half of the stimuli contained non-VSR/SR alternations such as *detain-detention*. In the learning phase the subject was trained to respond "YES" to the positive tokens and "NO" to others. Some additional pairs representing the VSR/SR patterns and non-VSR/SR patterns were used in the test phase, together with pairs of words representing the three test patterns: [aw-ʌ] as in *profound-profundity*, [uw-ʌ] as in *reduce-reduction*, and [ay-ɪ] spelled as *y*, as in *type-typify*. According to Jaeger, since

Table 2.11. Frequencies and Proportions of Responses in the Test Phase of Jaeger's Experiment (POS=positive reinforcement tokens, NEG=negative reinforcement tokens.)

Word type	Total N of response	"YES" Responses	"NO" Responses
POS	143	117(.82)	22(.15)
NEG	143	13(.09)	126(.88)
[aw-ʌ]	44	4(.09)	38(.86)
[uw-ʌ]	44	33(.75)	7(.16)
[ay-ɪ] *y*	44	34(.77)	9(.20)

SPE predicts [aw] to alternate with [ʌ], and does not predict an [uw-ʌ] alternation, while the SR does the reverse, any tendency for the subject to prefer the [uw-ʌ] alternation will indicate that the subject was really applying a spelling rule rather than the vowel shift rule. As shown in Table 2.11, the [aw-ʌ] alternation received 86% *negative* responses, close to the negative responses given to the negative reinforcement tokens (88%). On the other hand, the subjects gave 75% *positive* responses to the [uw-ʌ] pair, where the corresponding percentage for positive reinforcement tokens was 82%. From post-experimental interviews, Jaeger also found that most subjects attempted to define the target category in terms of spellings. She thus claimed that "the vowel alternations that naive speakers feel belong together in a group are those that are designated by the spelling system of English" (1984, p.30). But evidence also pointed to some form of phonological representation of the alternations because (1) two-thirds of subjects who reached criterion were not consciously thinking in terms of spelling; (2) alternations spelled with *y* were included in the category (77% positive responses), while word pairs spelled with the same vowel letters but not pronounced according to the alternations were rejected; and (3) subjects attending only to the sounds performed better than those attending also to the spelling. These considerations led Jaeger to opt for a long-short rule which she claimed the speakers have abstracted from orthography or from the learned "long-short" terminology. She proposes that speakers can access this abstracted rule without recourse to any particular orthographic representation. In other words, she claimed from these observations that the vowel alternations are psychologically real, but the attested reality differs in kind from the VSR Chomsky and Halle postulate. Rather than being based on sound alternations appearing in spoken forms, the alternations have their origins in orthography, and have been abstracted as the long-short rule.

There is no doubt that spelling conventions can influence subject's awareness of sound relationships, and this fact has been demonstrated by Armbruster's second experiment, as already noted. But it seems that linguists have a tendency to downplay the role of orthography in language (cf. Kiparsky and Menn, 1977). Orthography has been taken as a mere "reflection" of what people know about

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language, and ever since the structuralist era has played a secondary role. Chomsky and Halle's idea that the English orthography is a near optimal representation of a more fundamental "phonological" truth is also typical of such a position. But present-day North America is a highly literate society, and it is naive to expect that education, of which learning to write is a fundamental part, will not have influence on the speaker's knowledge of language. Therefore Jaeger is right in questioning that "If we learn something in school, is it any less psychologically real than if we have intuitively and unconsciously grasped it from the [spoken] lexicon?" (1980, p.237). Thus, there are at least three alternative sources from which the language user may come to grips with the vowel alternation relationships. The first is what SPE assumes, that of abstracting the relationship by learning the appropriate lexical items and relations between them, without reference to orthography. The second is that speakers, after learning to read and write, learns on their own that some letters have two (or more) pronunciations, and so use the orthography as the basis for relating the sounds. The third is that the speaker is explicitly taught by a teacher, for example, the "long" and "short" variants of a letter, such that no spontaneous learning need take place at all. But these three sources need not be mutually exclusive, and one can enhance the other. The job of the linguist is to establish the truth by the careful testing of the alternative hypotheses, and this is the direction of Jaeger's work. Thus she claimed that the vowel alternation relations were captured by what she called "long-short rule", which is really an orthography-based rule; and that the psychological reality for an orthography-independent vowel shift rule as proposed in SPE was not empirically supported.

Unfortunately, however, Jaeger's conclusion is weakened by Halle's (1977) version of the VS rule, since it was based on the assumption that the [uw-ʌ] alternation was part of a spelling rule and not a part of VSR. But as we have shown in section 1.1, Halle's (1977) version of the rule included [uw-ʌ] in the place of [uw-ɔ]. Under this reformulation the VS rule and the spelling rule make the same prediction about [uw-ʌ], and the subjects' acceptance of this alternation does not tell us whether it was the (new) VS rule or the spelling rule that was involved. The fact that subjects employed a "sound" strategy rather than a "spelling" strategy seems to favor the VS rule, but the phonologist is still faced with the need to explain why the [aw-ʌ] alternation, which is pivotal in VS operations, was rejected in both Jaeger's and Cena's studies.

2.2 Experiments on Word Structures

2.2.1 An Experiment on Word Formation Restrictions with *-ity*

Randall (1980) designed a test trying to find out whether English speakers are aware of etymological subclasses in their vocabulary. She tested Jespersen's (1954) distinction among Greek, Latin, French, etc., against a division into a "non-native" group (including Greek and Romance forms) vs. a "native" group proposed by Chomsky and Halle (1968), Aronoff (1976) and Siegel (1978). Four types of stems were used. They were LF (Latin stems which are familiar and have been incorporated into English), LU (Latin stems which have not been borrowed and are unfamiliar to most English speakers), G (Greek) and A (Anglo-Saxon). Stems of these four types were then combined with four types of affixes: latinate prefixes *con-* (*com-*, *col*), and *in-* (*im-*, *il-*, *ir-*); latinate suffixes *-al*, and *-ic*; non-latinate prefixes *syn-* (*sym-*, *syl-*) and *poly-*; non-latinate suffixes *-osis* (G), and *-ful* (A).

The ten morpheme structure types were matched with the four stem types to make a list of 40 stimulus words. The list was presented to 54 subjects for acceptability judgements. The subjects listened to the stimuli and rated their acceptability as possible English words along a 1 to 4 scale, 1 being perfectly acceptable and 4 being unacceptable. The following conclusions were drawn: (1) Latinate stems are preferred to nonlatinate stems before *-ity* and Greek and Latin stems form a homogeneous superset as opposed to native stems. (2) When *-ity* is added, subjects prefer the forms with latinate affixes regardless of the origin of the stem physically adjacent to *-ity*. (3) Homogeneity of stem type and affix type has some effect on the ratings, but the "adjacency effect" (homogeneity among affixes) is much more important. (4) The difference between LF and LU is significant. This indicates that word frequency can be a factor in determining whether a form is acceptable. Thus Randall claimed that "the results here do suggest a native speaker's ability to differentiate in some way among these classes," and that the distinctions made are consistent with the claims of Chomsky and Halle (1968), Aronoff (1976) and Siegel (1978).

This study supports the objection raised by Kiparsky (1975) concerning the use of Anglo-Saxon (or Germanic) stems before *-ity* in testing the psychological realities of vowel shift rule (Ohala, 1974; Steinberg and Krohn, 1975; see sections 2.1.1 and 2.1.2). Whereas I consider the general conclusion valid that English speakers do distinguish between such types of vocabulary, there are two points about the experiment that need to be discussed. The first is about the difference between LF and LU, which, as pointed out in conclusion (4) above, was significant, whereas Randall found that the difference between the LU and A types was not significant ($p > .05$). Examining the stimuli, we find the A type words included *earthicity*, *moonality*, and *syntoothity*. The inadequacy of such stimuli can be approached from two points. First the Anglo-Saxon roots used are very familiar ones (*earth*, *moon*, *tooth*). Although the subjects were instructed to observe only the phonological acceptability and not the semantic acceptability, it seems to me the familiarity of the stems will more or less induce the subject to try to associate the forms with a possible meaning, and thus may have been distracted from the phonological aspect. The rejection then may be resulted from their inability to make sense out of the forms. The second point comes from Kiparsky's (1975) criticism of Ohala (1974) and Steinberg and Krohn (1975). Kiparsky criticizes that these studies used noun forms before *-ity*, where usually adjectives are expected. This same criticism can be applied to Randall's study. *Tooth* does not change its word class by prefixing with *syn-*, and the nounness in *earth* and *moon* may be strong enough to defy an adjectival sense even with *-ic* and *-al* suffixed. These flaws in design will bias the results and cast some doubt on the distinction found between LU and A even more dubious. If this point is correct, we can conclude that latinate forms as a real class are probably a closed set, at least in the case before *-ity*.

Another bias in experimental design unfavorable to A forms is the use of *-ful* as a suffix before *-ity*. While *-ic* and *-al* suffixes can receive primary stress when added with *-ity* (as in *authenticity*, *formality*), *-ful* as a rule does not receive primary stress. Assigning stress to this syllable in test words like *phonifulity*, *youthfulity*, *plentifulity* certainly creates a weird feeling. The subjects might well have rejected the forms on that basis, therefore, rather than on the basis of homogeneity of the suffix in the context before *-ity*.[7]

2.2.2 Two Experiments on the Trisyllabic Laxing Rule

Chomsky and Halle (1968, p.241) formulated the laxing rule as follows:

$$\begin{bmatrix} \text{V} \\ \alpha\text{round} \\ \alpha\text{back} \end{bmatrix} \longrightarrow [\text{-tense}] \;/\; \underline{\quad} \;\text{C} \begin{cases} \text{C}_0 + \textit{ic}, + \textit{id}, + \textit{ish} \\ (\text{C},+) \begin{bmatrix} \text{-stress} \\ \text{V} \end{bmatrix} \text{C} \; [\text{-cons}] \end{cases}$$

This rule provides the environment for the lax member of the alternating vowel pairs to occur. The two experiments to be discussed, both done by Armbruster (1978), concerned the second part of the rule. The second part requires the vowels which agree in the values for [round] and [back] features to be lax in antepenultimate syllables. Some examples are *divinity*, *radical*, *gratify*. Since this thesis does not make assumptions on the directionality of derivation on the part of vowel alternations, it is reasonable to look for obligatory environments that dictate the occurrences of the lax variants, and observe if the native speakers can show awareness of vowel alternations in these environments.

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[7] Although *youthfullity* is listed in *Oxford English Dictionary*, it is marked as a "nonce word".

Armbruster's (1978) fourth and fifth experiments tested the reality of the trisyllabic laxing rule proposed by Chomsky and Halle. In Experiment Four, he constructed nine nonsense words, each with two varying pronunciations of the vowel in the antepenultimate syllable. Among them, *brenity*, *krenify*, *elamine* with [ɛ] and [iy], (e.g. *brenity* was given both as [brɛnəti] and [briynəti]), *granity*, *splanify*, *thanisate* with [æ] and [ey], and *progrimity*, *glinify*, *slinitude* with [ɪ] and [ay]. The nine words with tense vowels were matched with each of the nine words with lax vowels to make 81 pairs. Seventeen college students were asked which member of the pair they preferred.

The results showed that the subjects preferred the lax variants. Of the 81 pairs, the subjects chose the lax members from 43 to 58 times (i.e., from 53-72%). Among these test pairs, there were nine pairs which differed only in the alternating vowels. In these nine pairs, the subjects chose the lax variants from five to eight times. Hence it is clear that the subjects had a certain preference for lax vowels in these environments.

Some inferences about the strength of the antepenultimate environment can also be drawn. From the above figures we notice that the preference for lax vowels is clear but not overwhelming. Those who chose the lax variants 43 times were not too far from the expected random mean (40.5). If we do chi-square tests (goodness of fit) to examine how significant these choices are from the random mean, we find that nine of the 17 subjects (those choosing the lax variants 49 times or less) probably made their choices randomly ($p>.05$). This implies that the environments are anything but phonotactic-type constraints.

Yet another Armbruster's experiment, his Experiment Five, was to test if orthography can provide some influence on the strength of the environmental requirements. In his words, "Would subjects conform to the output of trisyllabic laxing rule, when visually presented with words (such as *krenify*), which could be pronounced in conformity with trisyllabic laxing (like *obsenity*) or in violation of it (like *obesity*), when the subjects had not been exposed to possible roots?" (p.99).

The same nine nonsense words as in the previous experiment were used as stimuli. Ten subjects were each given a list of stimulus words, and were asked to read the words aloud with the pronunciations they thought best fit the words. Among the total 90 responses, the subjects produced 84 (93%) lax vowels in the prescribed positions. Of the six non-lax pronunciations, four were tense vowels and two shifted stress positions.

Comparing the means of the scores of this experiment and of those of the nine pairs differing only in the antepenultimate vowel in the previous experiment, Armbruster found a significantly higher mean for scores in Experiment Five ($p<.01$). Thus he concluded that "the preference for conforming to the output of the trisyllabic laxing rule is motivated in part by the orthographic structure of the words, in addition to preference based on the phonetic structure alone" (pp.102-03).

The implication obtainable from these experiments is that trisyllabic laxing rule as a phonological rule has psychological reality, though it is only mildly operative.[*] On the other hand, orthography provides a very strong motivation for the laxing phenomenon. This once again shows the significant role orthography plays in the operation of language.

2.3 Summary of Previous Experiments

As shown in the above review of experimental studies done on the psychological reality of vowel shift rule, some studies produced negative results (Ohala, 1974; Steinberg and Krohn, 1975; the first experiment of Myerson, 1976a,b) while others produced more positive results (Moskowitz, 1973; Myerson, 1976; Cena, 1976; Armbruster, 1978; Jaeger, 1980). Viewing the positive evidence, different investigators drew different conclusions. Myerson proclaimed the reality of Chomsky and Halle's vowel shift rule, while Cena concluded that only the reality of some vowel alternations had been established. Moskowitz and Jaeger argued that the alternations were unrelated to a vowel shift rule and had their origins in orthography. Armbruster rejected the psychological reality of the vowel shift rule altogether and argued that the alternation performances are due to morpheme structure preferences, spelling conventions, and references to learned graphemic representations.

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[*] Notice that the experiments only tested front vowel alternations. The conclusions can not be automatically applied to back vowels series, which must be independently tested.

But looking at the successful experiments more closely, we can find some things in common which might lead us to a better understanding of the matter. Both Myerson's second experiment and Armbruster's first experiment employed a preference test. Myerson's subjects showed preference for VS patterns over NVS patterns, while Armbruster's subjects showed preference for the no change (NC) patterns over VS patterns. It thus seems possible to establish a hierarchy of preference, that of NC over VS over NVS. An examination of Cena's data also showed that the number of no-change responses drastically decreased after the third trial (see Table 2.12). This indicates that in the experiment, part of what the subjects learned through trials was that they were expected to change the vowels. Also, in the successful experiments we find that the experiments were all designed in such a way as to induce subjects to change vowels. The learning sessions in the experiments by Moskowitz, Myerson (Experiment III) and Jaeger did just that. Thus it seems fair to say that unless subjects are trained in some way to change vowel qualities, they will tend to preserve the original stimulus vowels in their responses. This would

Table 2.12. Number of No-change Responses over Trials in Cena's Experiment.

	Trials									
	1	2	3	4	5	6	7	8	9	10
# responses with no vowel change	11	9	10	2	3	3	2	0	0	1

account for the non-productivity associated with the production tests. This response strategy is only natural when one considers that the responses the subjects were to give were supposed to be derived from or related to the stimulus words.[7] While one can argue for the psychological reality of the trisyllabic laxing rule from the results of Armbruster's Experiments Four and Five, the environments provided by this rule are not strong enough to constitute a phonotactic constraint on a par with voicing assimilation in English plural formation. The laxing rule is apparently at a lower strategic hierarchy than the strategy to preserve the shap of original morphemic form. We can imagine that when a nonsense word was first learned, with or without meaning supplied, the most conspicuous aspect of the word was its phonetic aspect, and thus the most expressed relationship of two words one can show in this situation is maximum phonetic similarity.[18] Unless subjects are made to realize that responses with maximum phonetic similarity are not desired, little information about preferred vowel changes is likely to be forthcoming.

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[7] A similar point is made in Darden (1985). What is interesting to observe is that in Armbruster's first experiment, he explicitly told the subjects in both groups in the seventh week that they are expected to change vowels. But even after being so told, subjects in Condition I (cued with alternating stimuli) did only slightly better (20% VS responses in week 7 as against 14% in week 6), and subjects in Condition II (cued with nonalternating stimuli) did no better (4% in week 7 as against 6% in week 6).

If the previous argument is valid, then the conclusion follows that Chomsky and Halle's postulation of a single underlying vowel such as /ī/ for the varying pair [ay-ɪ] is questionable. All these experiments have shown that subjects were readily aware of the surface phonetic difference, unlike the case of [s] vs. [z] in English plurals, and such awareness must be expressed in phonological representations. It is of course possible to argue that forming a singular underlying representation is part of rule-learning. But since we can only infer from the evidence obtained so far that subjects are aware of surface phonetic differences, the burden of proof lies naturally on those who advocate the additional learning step of abstract unitary underlying representations.

Still, the successful experiments clearly indicate that when subjects did change the vowels, they tended to do so in the direction of VS patterns. Two things are generally observed in these experiments. The first is that almost all the vowels when changed were changed into lax vowels. (Armbruster recorded only five change-to-tense responses

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[18] In the case of Ohala's and Steinberg and Krohn's experiments where real words were used, the elicited forms were new.

(the CT patterns) among the total 1512 responses in production task. Among the 5000 responses by Cena's subjects, only 30 such responses were found.) In other words, it seems plausible to assume that tense vowels are more "at odds" with each other than they are with lax vowels. The second significant observation is that simply laxing without "shifting" the vowels (the NVS pattern) seems less preferable than laxing with a concurrent "shifting" to the VSR pattern. This point is especially suggestive when we consider that a NVS variant is phonetically more similar to the original vowel than a VS variant is. However, such preference is based entirely on experiments with front vowels, and it is one of the purposes of this thesis to find out whether such preferences are also shown in back vowel alternations.

There is still another point which is relevant to all the experiments. The [aw-ʌ] alternation, which is held by all vowel shift theories published to date, has not demonstrated significance in *any* of these experiments. Nonetheless, even in the latest version of the theory (Halle and Mohanan, 1985), the theorists persist in including this pair as part of the vowel shift phenomenon. This is quite remarkable, for if the generative theory of linguistics is a theory of psychological constructs of language as it claims, then the theory should be subject to psychological disconfirmation. For one to be so obsessed with the theory as to defy the solid contrary evidence from so wide a range of experimental sources is simply unscientific. Therefore, the position of this thesis is that, while recognizing that speakers have some kind of knowledge of vowel alternation, we set out to investigate what alternations are involved, and how best to account for them. Rather than trying to prove or disprove (portions of) the vowel shift rule, we are interested in understanding the vowel alternation phenomenon, regardless of the consequences for any particular theoretical position.

Some inferences can also be drawn from the word structure experiments. In Randall's study, she showed that native speakers of English possess knowledge of types of words with different etymological sources, and the well-formedness of word structures in terms of these word types. Kiparsky (1975) questioned Steinberg and Krohn's use of Germanic roots before *-ity*'s. This criticism stands in light of Randall's study. Chomsky and Halle (SPE, p.178) also noted that the VS alternations are found primarily "in the subpart of the vocabulary that is of Romance origin." Thus is seems that the VS rule, if true at all, is of limited scope, and cannot be properly regarded as "the pivotal process of Modern English phonology" (SPE, p.187).

There is also the implication of orthographic influence on the vowel alternation phenomenon to be drawn. In Steinberg and Krohn's (1975) study, when the subjects were given written stimuli, they produced slightly more expected VS responses than when they were given oral stimuli.

Armbruster's experiment II showed the effect of orthographic influence on the vowel shift phenomenon; and his experiment V, contrasted with experiment IV, showed that the subjects were more prone to produce lax variants before *-ity*, *-ify*, and so on when the stimuli were presented in written forms. Moskowitz and Jaeger also argued that their subjects performed on the basis of orthographic rules. On the basis of these findings, we can reasonably conclude that orthography can influence the vowel alternation activities in substantial ways. To say the very least, it provides a reliable foundation on which the VS alternations can find a place.

Chapter 3

Experiments

In an attempt to resolve some of the questions left unanswered by prior research on the nature of the vowel shift phenomenon in English, we conducted three experiments: a preference test, a production test, and a concept formation test. From the previous discussion, we have seen that some of the prior experiments explored only part of the phenomenon, and the results may have been biased, since it was found that the alternation patterns may have different strengths. With this realization, we have incorporated into our tests all of the patterns that seemed to be relevant. Our attention is especially directed to the problematic area of back vowels.

3.1 Preference Test

The purpose of this experiment was to try to get a fuller picture of speaker preferences, when asked to choose between two vowels before *-ity* given a tense vowel stimulus. It was suggested earlier that, as Myerson's and Armbuster's studies show, a preference hierarchy of no change (NC) over vowel shift (VS) over no shift (NVS) pattern seems to be operative. While the tendency to analogize the derived *-ity* form with its base form is very strong in this situation (Armbruster's Experiment I), the preference of the VS pattern over the NVS pattern is not so clear. Myerson reported only a 63% preference for the VS pattern. Compared with the 83% preference for the NC pattern over the VS pattern, the preference for the VS pattern over the NVS pattern is not impressive. Furthermore, Myerson tested only two alternations, [ey-æ] and [iy-ɛ]. We cannot be sure if in other comparisons the preferences will be as strong. Besides, Myerson's comparisons were only made between VS and NVS alternations. While such comparisons are reasonable, we feel that provisions should be allowed for other possible competing patterns. Therefore in the present experiment, comparisons were made among all lax vowels.

In order to make the size of the test manageable, the change-to-tense (CT) patterns and no-change (NC) patterns were excluded from the study. This practice is justified on two grounds. First, by inference from Armbuster's preference test and other production tests, I assume that the subject will tend to analogize the derived form to the base form and choose a no change pattern over any vowel change. Since the analogy effect is not the point of interest here, and since the inclusion of this type of comparison will reduce other possible effects, comparisons with unchanged vowels were excluded from the experiment. Secondly, as mentioned in section 2.2.8, if subjects change the vowel, they are not likely to change it into another tense vowel. In other words, the CT pattern is assumed to be at the bottom of the preference hierarchy. It is the "middle ground" — the lax vowels — that we are interested in, where the VS pattern, the NVS pattern, and possibly other patterns reside.

3.1.1 Subjects

Forty-one students of introductory linguistics were tested in two groups; all of them were native speakers of English. The testings were done in class. Thirty-one of the students received the stimuli in one order, and the remaining ten did the reverse order. The difference in group sizes was due to the imbalance in class sizes.

3.1.2 Method

Six nonsense words were constructed, each containing one of the tense vowels [iy, ey, ay, uw, ow, aw]. Following Cena (1976) and the advice of Randall (1980), six latinate prefixes were used. Furthermore, as the effect the post-vocalic consonants have on the vowel has been demonstrated by Armbruster's experiment III (section 2.1.1.4), the six consonants [v, s, l, d, m, n] were chosen in this position. It was thought that this would enhance naturalness because these consonants are fairly common in this position, as in such words as *activity*, *verbosity*, *formality*, *commodity*, *proximity*, and *divinity*. The following is the list of nonsense base words used in this experiment:

[prədiyv]
[ɪksbeym]
[səbtays]
[mɪstruwn]
[dɪskowl]
[ɛmpawd]

The naturalness of these words was approved by two native speakers in the Department of Linguistics. For each base word, six derived *-ity* words with lax vowels [ɪ, ɛ, æ, ʊ, ʌ, ɔ] were then constructed for comparison. Each derived word was compared with five other derived words, one at a time, which made 15 comparisons in each tense vowel category, or 90 comparisons in total. For each paired comparison there are two possible presentations: either A-B or B-A. This presentation order was balanced across the six base-word categories. Within each category, each derived word appeared five times. The presentation was made such that each derived word appeared as the first member of the comparison two or three times and as the second member two or three times. The comparisons were then randomized, but two comparisons having the same base word were kept at least two presentations apart. Two test orders were administered, each the reverse of the other both in the presentation of the items (item 1 in one order was item 90 in the other) and in the order of pair members (comparison A and B was A-B in one order and B-A in the other). The instructions and comparisons (see Appendix I) were recorded onto magnetic tape through a TEAC-7030 tape recorder by a female native speaker of English, in a sound-proof room. There was a two-to three-second lapse between items, just about enough time for the subjects to mark the answers (A or B) on the optical scoring sheets with pencils. The tape was played back on the same tape recorder through a Sony TA-1066 amplifier and a loudspeaker placed in front of the subjects. After the subjects listened to the instructions, there was a pause for questions to make sure they all understood what was expected of them. As no questions were raised, the stimuli were then played, with a rest break of about five minutes after the 45th comparison.

3.1.3 Results

The frequencies of the preference choices are shown in Table 3.1. Since in each category there was a total of 615 responses, completely random choices would assign the value 102.5 to each cell. Thus any frequency under 103 was considered insignificant. On this criterion, we can identify three significant competing alternation patterns in all categories except [iy], which had only two. Following McCawley's taxonomy of possible patterns (see p.16), Table 3.2 was constructed to show the dominant patterns in each category, in the order of frequency. Notice that since McCawley did not include lax [ʊ] in his chart, and none of the [ʌ] responses in our results were significant, [ʊ] was taken to be the NVS variant of [uw], which ranked a close third in the category.

Table 3.1 Frequency of Choices Made toward each Derived Vowel in Preference Test (Frequencies over 103 are starred. Highest possible number in each cell is 205.)

	Derived					
Base	ɪ	ɛ	æ	ʊ	ʌ	ɔ
prədiyv	167*	161*	75	72	85	55
ɪksbeym	116*	179*	152*	37	51	80
səbstays	192*	118*	115*	28	80	82
mɪstruwn	114*	135*	95	112*	70	89
dɪskowl	78	116*	135*	62	98	126*
ɛmpawd	142*	165*	69	60	64	115*
Total	809	874	641	371	448	547

Table 3.2 Ranks of Dominant Patterns in Categories on Preference Test

	Category					
Rank	iy	ey	ay	uw	ow	aw
1	NVS	NVS	VS	BVS	BVS	BIVS
2	VS	VS	AVS	BNVS	VS/NVS*	BVS
3	(N/A)	AVS	NVS	NVS	BNVS	NVS/AVS*

* These patterns are ambiguous. See the chart on p.16.

In the front series the NVS and VS patterns were dominant. But in the [iy] and [ey] categories, the preference orders were just the opposite of Myerson's results, though the difference was not as great (combined percentage 53.7% (NVS) vs. 47.3% (VS)). In the back series, six of the nine prominent patterns involve the change of [±back] feature; that is, the subjects were responding in these patterns with front vowels. The motivation is difficult to determine. Some of the responses might have followed analogy. For example, the predominent choice made to [dɪskowl] is [dɪskælətɪ], which one can attribute to analogizing with real English forms such as *formality*, *morality*; that is, the subject might have abstracted *-ality* as a suffix because of its frequency. An examination into the real English words shows this. Among the 1618 *-ity* words tabulated (see Appendix IV), 191 (12%) of them end in *-ality*.[1] Considering the large number of possible vowel-consonant combinations, this percentage is very high. Myerson (1976a, p. 147) reported a similar abstraction of such suffixes by her subjects. In her recall test, some subjects (in all grades) erred by adding not the required *-ity* but *-ality*, *-idity*, *-acity*, *-icity*, and *-erity*. Myerson attributed this phenomenon to the great number of words with these endings, which may very well be the reason.

In the [uw] category, some of the choices made to [mɪstrɪnətɪ] may also be attributed to analogizing with *trinity*. Similarly, [ɛmpɪdətɪ] from [ɛmpawd] was chosen 142 times, a result which may be attributed to the analogical influence of such words as *stupidity* and *validity*. But others are more difficult to explain. The base [ɛmpawd], for example, was associated most with [ɛmpɛdətɪ], but there is no linguistic theory, to my knowledge, that can provide a reasonable explanation for this association.

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[1] Not including *quality*, *equality*, and *inequality*, which exhibit the vowel [ɔ], not [æ].

Table 3.3 Number of English Words with Various Vowel-Consonant Combinations

Ending	Vowel before -*ity*					
	ɪ	ε	æ	ʊ	ʌ	ɔ
-*V*vity	38†	3	6	0	0	0
-*V*mity	15	2	2	0	0	1
-*V*sity	66	0	32	0	0	95
-*V*nity	22	5	16	0	0	0
-*V*lity	47*	2	191	0	1	9
-*V*dity	56	2	0	0	0	5
Total	244	14	247	0	1	110

†30 of these are -*tivity*.
*Not including -*bility*, which would add another 355 to this category. (No -*bility* words were included in any of our experiments.)

Table 3.4 Frequencies of Word Occurrences with Various Vowel-Consonant Combinations (according to Carroll *et.al.*, 1971).

Ending	Vowel before -*ity*					
	ɪ	ε	æ	ʊ	ʌ	ɔ
-*V*vity	537	3	328	0	0	0
-*V*mity	6	6	3	0	0	0
-*V*sity	511	0	82	0	0	174
-*V*nity	39	13	94	0	0	0
-*V*lity	211	13	335	0	0	486
-*V*dity	68	24	0	0	0	27
Total	1372	59	842	0	0	687

In an attempt to find out how much influence the analogical effect had on the subjects' preferences, Tables 3.3 and 3.4 were constructed. These tables show frequencies of real English words with regard to different vowel-consonant combinations, as extracted from Dolby and

Resnikoff (1967), Stillman (1965) and Caroll *et. al.* (1971) (see Appendix IV). Rank order correlation analyses were done comparing the frequencies in Table 3.1 with those in Tables 3.3 and 3.4. Three correlation coefficients turned out to be significant. Comparing the [ey] row of Table 3.1 (associated with [ɪksbeym]) with the -*Vmity* rows in Tables 3.3 and 3.4, we obtained Kendall's tau-*b* values of .64 and .70 respectively, both significant at the .05 level (one-tailed probability). But looking at Tables 3.3 and 3.4, the frequencies of -*Vmity* are too low to be of interest. The third significant correlation was found when comparing the frequencies in the [ow] row of Table 3.1 (associated with [dɪskowl]) with the -*Vlity* row of Table 3.3 (tau-*b*=.60, one-tailed $p<.05$). Thus it seems that the only strong influence the analogical effect had on the subject preferences was with -*Vlity*'s.

3.2 Production Test

As mentioned earlier, the previous production-type experiments were all quite unsuccessful. It has also been pointed out that since the vowel alternation process is not automatic, it generally occurs at a conscious level. With this realization, the production test reported below took a different approach. Instead of only asking the subject to produce new forms of his own choosing, the experimenter specifically required the subject to *change* the original vowel to another vowel while producing the new forms. In other words, our attention was directed to how the vowels are to be changed, rather than whether the vowels should be changed at all.

Bybee and Slobin (1982) and Bybee and Moder (1983) presented experimental evidence for the "schema theory", where they argued that the generalizations the speakers make about irregular forms are "product oriented" rather than "source oriented" (Zager, 1981). That is, the kinds of irregular forms produced were usually dependent on what kind of morphological classes were involved, not merely on the phonological form of the source words. In their studies, they found that the subjects tended to produce irregular past forms with the vowel [ʌ], regardless of what the source vowels in the present tense. This finding contradicted with the traditional, source-oriented view that the kind of forms produced depends crucially on the source forms (e.g. Hoard and Sloat, 1973).

Chomsky and Halle claimed in SPE that the Vowel Shift Rule is "the pivotal process of Modern English phonology" (see p.2). Because the rule is assumed to be a phonological process, it presumably ought to apply generally across morphological categories. Therefore, for example, the rule accounts for the vowel alternations in *profane-profanity*, *child-children*, and *lose-lost*, even though the three pairs come from different morphological classes. This of course is a typical "source-oriented" approach. In this study, our objective was to find out whether subjects perform differently in different morphological situations (the "object-oriented" approach) or the same (the "source-oriented" approach).

Three experimental conditions were set up. In the first condition, the subject was asked to modify the vowel in the base adjective form to another in a noun form ending in *-ity*. In the second condition, the subject was asked to modify the vowel in the base (present tense) verb form to another in the past form. In the third condition, the subject was asked to modify the vowel in the base (singular) noun form to another in the plural form. We have shown in Chapter 2 that quite a number of studies were done using *-ity* as the environment for VS activities. We expect this environment to be fairly productive for the VS alternations. However, it is also of interest to see if the effect the object-oriented (or "product-oriented") strategy has on the vowel modifications. We would also like to observe whether the VS alternations also appear in the other two conditions, viz., in the pluralization and past formation processes.

3.2.1 Subjects

Ninety-one subjects were recruited from an introductory linguistics class at the University of Alberta to form the UNIV group, and seventy-two 11th and 12th graders were recruited from second language classes at Strathcona Composite High School in Edmonton to form the HS group. They were all native speakers of North American English and participated in the experiment on a voluntary basis. Each subject was tested individually in a session of from 10 to 15 minutes in length.

The rationale behind selecting subjects as we did has to be explained. It has been demonstrated by Myerson's experiments (especially her recall test, see section 2.1.3.1), that the developmental factor is important in bringing out VS activities, as her older subjects were progressively more successful. To maximize the possibility of VS activity in our experiment, we therefore used eleventh and twelfth graders, and beginning university students as our subjects. But as the university students are more or less a selected group, we also wanted to see if the high school students, who we believe are more representative of ordinary language users, would demonstrate comparable behaviors.

3.2.2 Method

Thirteen vowels, [ay, ey, iy, aw, ow, uw, ɪ, æ, ɛ, ʊ, ɔ, ʌ, ɔy], were used in constructing 26 nonsense stems. Each stem was of the (C)CVC pattern. There were 14 consonants used in the post-vocalic positions. They were [p, t, k, b, d, g, m, n, l, f, v, s, z, š]. Different post-vocalic consonants were used for the two replicates of the same vowel. After these stems were constructed, they were offered to native speakers of English in the Department of Linguistics for well-formedness judgements. In order not to bias toward VS responses, the derived VS counterparts were also checked to see if they would remind the subjects of real English analogues. The same 26 stems were used in all three experimental conditions. Each subject was assigned to one of these three conditions and made to perform either the nominalization task (Condition I), the past formation task (Condition II), or the pluralization task (Condition III). For the purpose of making the forms sound more like Romance words, the nonsense adjectives all had Romance prefixes, although they had the same roots as the other two test conditions. Thus, while *stice* was used both as a verb and a noun, *prestice* was used as an adjective. (For the instructions and lists of nonsense stems used in the study, see Appendix II.)

In Condition I, the subjects were told that there are some English adjectives that have corresponding noun forms ending in *-ity*, and *divine-divinity*, *serene-serenity*, *profound-profundity* were given as examples. It was also pointed out to them that besides adding *-ity* to *divine*, *serene*, *profound*, the vowel had changed. Then the subjects were taught 26 artificial "adjectives" in the following frame:

> *Prestice* means *capable of leading others*.
> Mrs. Smith is capable of leading others.
> She is a *prestice* lady.
> She has a lot of ___________.

The subject was asked to complete the last sentence by providing a noun form ending in *-ity* with a *vowel change* in the stem. The subjects in this condition (30 university students and 24 high school students) form the Nominalization (NOM) task group.

In Condition II, the subjects were first shown that some English verbs have irregular past tense forms, as in *throw-threw*, *mean-meant*, *run-ran*. It was pointed out to them that these forms, instead of adding a regular past tense ending to the words, changed the internal vowel. Then the subjects were shown 26 pictures with people or animals performing various unfamiliar actions. The subjects were taught the nonsense words in the following frame:

> This is a girl/boy/dog/etc. who knows how to *stice*.
> He/She/It *stices* every day.
> He/She/It did the same thing yesterday.
> Yesterday he/she/it _____.

In each item, the subject was asked to complete the last sentence by providing an irregular past tense form with a *different vowel* from the base verb. The subjects in this condition (31 university students and 24 high school students) constitute the Past Formation (PAST) task group.

In Condition III, nouns with irregular plural forms, exemplified by *man-men*, *foot-feet*, *child-children*, were first shown to the subjects. The fact that these plurals involved a vowel change from the singular form was also pointed out to them. Then the subjects were shown pictures of 26 unfamiliar creatures. For each item, the subject was taught the name of the creature in the following way:

> Here is a *stice*.
>
> Now, here is another *stice*.
>
> There are two of them in the picture.
>
> There are two __________.

The subjects were asked to complete the last sentence by providing the irregular plural form with a *vowel change*. The subjects in this condition constitute the Pluralization (PLUR) task group.

In all three groups, if the subject produced a form without a vowel change, the experimenter pointed this out and asked the subject to try again. If the subject tried three times in vain, the experimenter marked the item as a "null response" and went on to the next.

In each task group, there were two order groups. This was accomplished by reversing the order of presentation of the items for successive subjects.

The instructions and item presentations were read individually to the subject by the experimenter to create a spontaneous atmosphere. The experimenter paid particular attention to the pronunciation of the source vowel, and asked the subject to repeat the nonsense source word in each item. After a satisfactory response was obtained, the experimenter repeated the response and asked the subject if it was what he/she said. In this way the experimenter was able to insure the correctness of transcription. Recordings were also made for later assessment, should any doubts arise.

3.2.3 Results

The results of the three task groups are presented separately in the following sections.

Nominalization

There were 54 subjects who worked on transforming adjectives into *-ity* forms. Of the total 1404 responses (54 x 26), there were 23 non-tabulated null responses. Among the source vowels, [ʊ] caused the most null responses (4), followed by [aw], [uw], [ɪ], [ɔ] and [ɔy], each with 3 null responses. There were 2 null responses in [æ] and 1 in [ay] and [ow]. The null responses included a [pɚvyuwšəti] answer to [pɚvuwš], and two [dəmwabəti] answers to [dəmɔyb]. In the first case, the subject (a high school student) prefaced [y] to [uw], and in the second case, the subjects (one university student and one high school student) were probably influenced by the French pronunciation of the "OI" spelling. In both cases, the subjects obviously thought they had adequately changed the vowel as required, so in order not to cause undue confusion, these responses were accepted; but since they were not classifiable in our study, they were regarded as null responses in the analysis.

The frequencies of responses to each vowel are shown in Table 3.5. Before going into the discussion of the frequencies in this table, we have to first clarify the question of the reliability of these frequencies, as each cell in Table 3.5 has actually collapsed the numbers of responses made to two different forms. For example, in the [ay-ɪ] cell, the frequency 60 is the number of [ɪ] responses made to [prɪstays] and [ɛmprayl], with no indication of how many responses were [prɪstɪsəti] and how many were [ɛmprɪləti]. This is a question of inter-item variation. Another question concerns intra-subject variation, that is, whether the subjects were responding consistently to the same base vowel.

On the first question, Table 3.5 is broken down in Table 3.6, where items with the same base vowel are differentiated. We can see from the high frequencies marked that the response profile is very similar to that of Table 3.5. Take the [ay-ɪ] pattern, for example. There were 29 [prɪstɪsəti] responses and 31 [ɛmprɪləti] responses. In some other cases the high frequencies of the two items with the same base vowel were not so close, but they generally stayed the highest on both items containing the same tense vowel. There were three exceptions, however. In the [ɪ] rows, the highest frequency for [ɛkshɪg] ($ɪ_1$) went to [æ], while the highest frequency for [ɛmplɪt] ($ɪ_2$) went to [ay]. In the [ɛ] rows, the highest frequency for [mælbɛp] ($ɛ_1$) went to [ɪ] while the highest for [ɛnvɛl] ($ɛ_2$) went to [æ].

Table 3.5 Response Frequencies for Nominalization Task Group. (Underlined cells are highest frequencies among source vowels (rows). Starred cells are highest among the object vowel categories (columns). Frequencies of 9 or lower are insignificant. Italicized cells are VS responses. N=54.)

Source	Response Vowel												
Vowel	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay	0	8	4	2	1	0	*60**	8	10	0	12	0	2
ey	0	0	2	2	0	1	16	7	*74**	0	6	0	0
iy	7	1	0	2	0	0	37	*43**	13	0	5	0	0
aw	0	2	2	0	5	9	22	7	7	0	48	*2*	1
ow	0	1	2	5	0	5	9	6	9	0	*67**	3	0
uw	0	6	2	5	9	0	17	6	10	0	*49*	*1*	0
ɪ	*27**	4	10	1	0	1	0	13	32	0	17	0	0
ɛ	4	5	*18**	0	4	2	32	0	24	0	18	1	0
æ	1	*37**	3	1	1	0	22	18	0	0	22	1	0
ʊ	3	1	0	2	5	10*	20	9	10	0	39	4	1
ɔ	1	3	0	1	*32**	*2*	28	20	16	0	0	1	1
ʌ	2	0	1	*0*	2	*8*	32	7	22	9	25	0	*0*
ɔy	3	3	3	2	4	5	21	7	10	0	45	*2*	0
TOTAL	48	71	47	23	63	43	316	151	237	9	353	15	5

In the [ɔ] rows, [prɪslɔn] (ɔ$_1$) produced [prɪslɪnəti] most frequently, while the majority of [ɛkspɔv] (ɔ$_2$) went to [ɛkspowvəti]. As we can see, in these inconsistent cases the source vowels were all lax, and in each of the [ɪ] and [ɔ] rows, one of the high frequency involved a tense vowel. These tense responses, [ay] (←[ɪ]) and [ow] (←[ɔ]), bear VS relationships with the source vowel. It is reckoned that, while lax vowels are more natural before *-ity* (Armbruster's experiments IV and V), these VS alternations succeeded, at least partially, in breaking away from this constraint. The inconsistency in the [ɛ] rows is more difficult to explain, because the high frequencies in both cases fall in lax vowel

Table 3.6 Frequencies of Responses to Individual Items in the Nominalization Task. (High frequencies in each source vowel category are underlined, and VS response cells are italicized. R$_1$ and R$_2$ are totals of the first and second replications, respectively.)

	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay$_1$	0	2	2	1	0	0	*29*	5	5	0	10	0	0
ay$_2$	0	6	2	1	1	0	*31*	3	5	0	2	0	2
ey$_1$	0	0	1	2	0	1	9	3	*32*	0	6	0	0
ey$_2$	0	0	1	0	0	0	7	4	*42*	0	0	0	0
iy$_1$	5	0	0	1	0	0	18	*19*	9	0	2	0	0
iy$_2$	2	1	0	1	0	0	19	*24*	4	0	3	0	0
aw$_1$	0	1	1	0	2	4	13	6	4	0	21	*1*	0
aw$_2$	0	1	1	0	3	5	9	1	3	0	27	*1*	1
ow$_1$	0	0	1	3	0	2	3	5	4	0	*34*	1	0
ow$_2$	0	1	1	2	0	3	6	1	5	0	*33*	2	0
uw$_1$	0	3	0	2	5	0	6	2	7	0	*26*	*1*	0
uw$_2$	0	3	2	3	4	0	11	4	3	0	*23*	*0*	0
ɪ$_1$	*11*	2	6	1	0	0	0	6	20	0	7	0	0
ɪ$_2$	*16*	2	4	0	0	1	0	7	12	0	10	0	0
ɛ$_1$	3	1	*10*	0	0	1	21	0	10	0	8	0	0
ɛ$_2$	1	4	*8*	0	4	1	11	0	14	0	10	1	0
æ$_1$	0	*16*	1	1	0	0	9	10	0	0	16	0	0
æ$_2$	1	*21*	2	0	1	0	13	8	0	0	6	1	0
ʊ$_1$	1	1	0	1	3	3	8	6	4	0	23	3	0
ʊ$_2$	2	0	0	1	2	7	12	3	6	0	16	1	1
ɔ$_1$	0	2	0	0	*9*	0	18	11	10	0	0	1	0
ɔ$_2$	1	1	0	1	*23*	2	10	9	6	0	0	0	1
ʌ$_1$	0	0	0	*0*	2	*4*	18	1	8	9	12	0	*0*
ʌ$_2$	2	0	1	*0*	0	*4*	14	6	14	0	13	0	*0*
ɔy$_1$	1	3	0	0	3	3	9	2	7	0	24	*1*	0
ɔy$_2$	2	0	3	2	1	2	12	5	3	0	21	*1*	0
R$_1$	21	31	22	12	24	18	161	76	120	9	189	8	0
R$_2$	27	40	25	11	39	25	155	75	117	0	164	7	5
TOTAL	48	71	47	23	63	43	316	151	237	9	353	15	5

categories. One may suggest that the high frequency of [ɛnvæləti] was due to the probably stereotyped form *-ality*. (We will discuss the frequency and analogical effects further in later sections.)

As to the second question about intra-subject variation, Table 3.7 should give us a clue of what was happening. The frequencies in this table show the number of subjects who responded consistently to both items of the same base vowel. Thus, for example, 21 subjects responded with [ɪ] to both [prɪstays] and [ɛmprayl]. The percentage of inconsistent answers is great (54%), but if we ignore the inconsistencies and look at the high frequencies, we see that the high frequency profile is almost identical to that in Table 3.5. What is interesting to note is that in the three inconsistent response pairs in Table 3.6, two of the pairs ([ɪ-ay], [ɪ-æ] and [ɛ-ɪ], [ɛ-æ]) are tied in Table 3.7, and the other pair ([ɔ-ow] and [ɔ-ɪ]) differ by only one point. Therefore Table 3.5 gives a quite accurate index of what the subjects' real performances were in the task.

Another consideration relates to the possibility of differences between the university students and high school students. Because we have seen quite significant VS activity in this task, it was possible for us to translate the responses into VS scores. For each subject a VS score can be calculated by dividing the number of correct VS responses (both tense to lax and lax to tense) by the total number of responses. Comparisons then can be made between

Table 3.7 Number of Subjects Who Made Consistent Responses to Each Vowel Category in Nominalization Task. (Underlined cells are highest within the source vowel category and italicized ones correspond to VS responses.)

Source	Response Vowel												
Vowel	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay	0	0	0	1	0	0	*21*	0	1	0	2	0	0
ey	0	0	1	0	0	0	4	1	*29*	0	0	0	0
iy	0	0	0	1	0	0	9	*13*	2	0	0	0	0
aw	0	1	0	0	1	2	8	0	1	0	16	*1*	0
ow	0	0	0	1	0	1	2	0	1	0	*24*	0	0
uw	0	1	0	1	3	0	5	0	2	0	*17*	*0*	0
ɪ	*7*	0	1	0	0	0	0	1	7	0	3	0	0
ɛ	0	0	*5*	0	0	0	6	0	6	0	2	0	0
æ	0	*13*	0	0	0	0	5	5	1	0	3	0	0
ʊ	1	0	0	1	0	3	4	2	2	0	14	0	0
ɔ	0	0	0	0	*7*	*0*	6	5	3	0	0	0	0
ʌ	0	0	0	*0*	0	*1*	6	1	3	0	4	0	*0*
ɔy	1	0	0	0	0	1	6	1	1	0	13	*0*	0
TOTAL	9	15	7	5	11	8	82	29	59	0	98	1	0

the two age groups. Three *t*-tests were performed based on three theoretical models. For the SPE model, 12 patterns were considered. These were [ay-ɪ], [ey-æ], [iy-ɛ], [ow-ɔ], [aw-ʌ], [uw-ʌ], and their lax to tense counterparts. A *t*-test showed no significant group difference with this model (t=1.34, p>.10). For Halle and Mohanan's (1985) model, 14 patterns were considered. These included the above alternations with [uw-ʌ] replacing [uw-ɔ], and [ʌ-uw] replacing [ɔ-uw]. The alternations [ɔy-ʌ] and [ʌ-ɔy] were also added. The results of the *t*-test were identical to those from SPE model (t=1.34). We also considered the spelling rule model with 10 patterns. These patterns were [ay-ɪ], [ey-æ], [iy-ɛ], [ow-ɔ], [uw-ʌ] and their lax to tense counterparts. There was also no significant group effect in this account (t=1.25, p>.10). Therefore in the following discussions, we will refer mainly to Table 3.5, with the two age groups collapsed.

The most striking feature we can observe in Table 3.5 is that the subjects preferred [ɔ] and [ɪ] in their responses. The frequencies of these two response vowels comprised almost half of the total responses. (Excluding the 23 null responses, there were 1381 responses in total, of which 48% were [ɔ] or [ɪ].) Such preference probably had its source in the frequency of these vowels before *-ity*. Appendix IV lists English words with *-ity* endings, together with frequencies of occurrence recorded in Carroll *et. al.* (1971). The number of words with a particular vowel, and the frequency of occurrence of the word are referred to as "type" and "token" frequencies respectively. Table 3.8 shows the frequencies of responses observed in this test, contrasted with the type and token frequencies from Appendix IV. The rank order correlation between the Test frequency and Type frequency is significantly high (Kendall's tau-b=.53, one-tailed p<.01), and the correlation between the Test frequencies and Token frequencies is also high (tau-b=.44, one-tailed p<.05). Considering the possibility that very high frequencies associated with *-bility*, *-ality*, and *-larity* may have caused these forms to have been stereotyped, we did another correlation analysis. The frequencies in the parentheses under [ɪ], [æ] and [ɛ]

Table 3.8 Frequencies of Response Vowels in Nominalization Task Contrasted with Real English Type and Token Frequencies of Words with *-ity* endings. (Figures in parentheses in [ɪ], [æ] and [ɛ] columns are frequencies after the stereotyped endings *-bility*, *-ality*, *-larity* have been removed.)

	ɔ	ɪ	æ	ɛ	ey	ow	ay	iy	uw	aw	ʌ	ʊ	ɔy
Test	353	316	237	151	71	63	48	47	43	23	15	9	5
Type	142	616 (261)	251 (60)	113 (81)	1	1	0	27	51	0	13	10	0
Token	1256	2200 (1401)	845 (510)	739 (602)	0	0	0	12	847	0	0	149	0

columns in Table 3.8 are those after the frequencies of the above three forms had been removed. The other frequencies remained the same. On the basis of these modified frequencies we did the same analysis. The correlation between Test and Type is high (tau-*b*=.53, one-tailed $p<.01$), and that between Test and Token is also high (tau-*b*=.41, one-tailed $p<.05$). Both analyses gave us significant results. Therefore we have reason to believe that the subjects' performances in this task may have been influenced by word frequencies.

Though we may infer from the above results that the subjects' performances were primarily "object-oriented", we can still see some interesting VS activities in this task.

There are five high response frequencies in Table 3.5 that fall outside of the two preferred vowel patterns. Four of these five ([ey-æ], [iy-ɛ], [æ-ey], [ɔ-ow]) are accountable by VS patterns. The only exception is with the [ɪ] category, in which subjects favored [æ] as their responses. But in this category, the [ay] response frequency (27) is significantly higher than all of the other types except [æ]. Altogether there are 7 high frequencies which correspond to the VS pattern (SPE model). Thus it seems as though the VS phenomenon had some power on the alternations of vowels in this task. We can also infer from this observation that different VS patterns had different strengths. For example, the [ey-æ], ([æ-ey]) connection is so strong that it could break away from the two preferred response patterns in both the tense-lax and the lax-tense cases. As a matter of fact, the [ey-æ] pattern has the highest frequencies in both the tense-lax category (74) and the lax-tense category (37). Among the four patterns with demonstrated reciprocal or bidirectional strength in this task, the [iy-ɛ] pattern was the weakest. As the design of the experiment can be viewed as repeated treatments, with VS responses expected for different stimuli, the Cochran's Q statistic (Winer, 1971) is appropriate to test the difference between [iy-ɛ] and [ey-æ], the strongest pattern observed in Table 3.7. A comparison among the VS responses for the four words containing the source vowels [ey] and [iy] shows that the difference is indeed significant (Q=25.77, df=3, p<.05). As

Table 3.9 Results of Cochran's Q Tests Comparing VS Responses between [ey] and [iy] (α=.009, '*' indicates a significant value).

\Frequency	[ey$_2$-æ] 42	[ey$_1$-æ] 32	[iy$_2$-ε] 24	[iy$_1$-ε] 19
[ey$_2$-æ]	—	6.25	10.80*	16.03*
[ey$_1$-æ]		—	2.91	7.35*
[iy$_1$-ε]			—	1.47

the individual comparisons suggest (Table 3.9),[2] this difference is mainly due to the difference in the source vowels; i.e., the [iy-ε] responses are fewer than [ey-æ]. A similar comparison of the four words with the source vowels [æ] and [ε] also shows a significant difference (Q=16.76, df=3, p<.05). The individual comparisons, shown in Table 3.10,[3] again suggest that the difference in the source vowels is mainly responsible. Thus it is fair to say that [iy-ε] alternation is significantly weaker than [ey-æ]. The strengths in the [aw-ʌ], [uw-ʌ], and [ɔy-ʌ] patterns are virtually nil.

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[2] The significance level for this table is set at α=.009. This adjusted value is derived from the Bonferroni procedure (Myers, 1979, p.298):

$$EF \leq 1-(1-EC)^k$$

where EF=Error rate per family (in this case the overall comparison of the four responses); EC=Error rate per comparison (in this case the six individual comparisons); and the superscript "k"=number of comparisons (=6). Thus, when EF=.05, $EC \leq$.009.

[3] See note above.

Table 3.10 Results of Cochran's *Q* Tests Comparing VS Responses of [æ] and [ɛ] (α=.009, '*' indicates a significant value).

\Frequency	[æ$_2$-ey] 21	[æ$_1$-ey] 16	[ɛ$_1$-iy] 10	[ɛ$_2$-iy] 8
[æ$_2$-ey]	—	2.27	7.12*	9.94*
[æ$_1$-ey]		—	3.00	6.40
[ɛ$_1$-iy]			—	0.50

Recognizing the fact that the object-oriented strategy had great influence on performance, we felt that the picture of the source-to-object vowel alternation was somehow obscured. One way to mitigate this object-oriented perspective is to look at the frequencies of different source vowels with the same object vowel. Since the same object vowel is compared (columns in Table 3.5), we should be able to see which source vowel made the greatest contribution. The starred frequencies in Table 3.5 show such a profile.

From this profile, we see that the high VS frequencies in the source-to-object orientation are also high in this count. This suggests that even in the preferred vowel types, the greatest contributions also came from VS patterns. Besides these, there are two more high VS frequencies added, i.e. [ɪ-ay] and [ɛ-iy]. Thus, in this count, the four patterns [ay-ɪ], [ey-æ], [iy-ɛ] and [ow-ɔ] have demonstrated strength forward (tense to lax) and backward (lax to tense). The [uw-ɔ] shift which manifested strength in the source-to-object profile did not do so in the object vowel orientation. Of course one can attribute this to the fact that both this pattern and [ow-ɔ] had [ɔ] as the object vowel, only [uw-ɔ] was weaker than [ow-ɔ]. But the [uw-ɔ] alternation is still suspicious, because as we have seen, all the other patterns have shown reciprocal strength (i.e., tense-to-lax and lax-to-tense), and this is not true for the [uw-ɔ] pair. Though [uw-ɔ] is strong, the frequency of [ɔ-uw] is negligible (only 2). The [ɔ-uw] shift, of course, had to compete with [ɔ-ow], but the fact that its frequency was so low raised serious doubts about the validity of the pair. We will return to this point in the next chapter.

We have noted above that among the four VS pairs which have demonstrable reciprocal strength, [iy-ɛ] was the weakest. A similar observation can be made from the object vowel orientation. In the [iy] column, [ɛ] made the greatest contribution (18); however, the contribution made by [ɪ] was not too far behind (10). In the source-to-object profile, a similar case was also found in the [iy] row (response vowel [ɪ] was 37, [ɛ] was 43). The [iy-ɪ] alternation is an NVS pattern, the only one that came out to compete with the VS pattern. Table 3.11 shows a comparison between the activities of VS patterns and NVS patterns in those four tense vowel categories which showed reciprocal

Table 3.11 Chi-square Tests of VS and NVS Responses in Four Bidirectional Vowel Alternations. ($p<.05$ for starred chi-square values. The [ow-ɔ] pattern is not included as its VS and NVS variants coincide.)

Source Vowel	Response Type VS vs. NVS	Source Vowel	Response Type VS vs. NVS
ay$_1$	ɪ(29) æ(5) =15.56*	ɪ$_1$	ay(11) iy(6) =0.73
ay$_2$	ɪ(31) æ(5) =17.36*	ɪ$_2$	ay(16) iy(4) =6.05*
ey$_1$	æ(32) ɛ(3) =22.40*	æ$_1$	ey(16) ay(0) =14.06*
ey$_2$	æ(42) ɛ(4) =29.76*	æ$_2$	ey(21) ay(1) =16.41*
iy$_1$	ɛ(19) ɪ(18)=0.03	ɛ$_1$	iy(10) ey(1) =5.82*
iy$_2$	ɛ(24) ɪ(19)=0.58	ɛ$_2$	iy(8) ey(4) =0.75

strength of VS patterns.[4] It is quite obvious that only in the case of the source vowel [iy] did the NVS pattern even come close to the VS pattern. Chi-square comparisons showed that while in [ay] and [ey] the VS and NVS patterns were significantly different (all $p>.05$, except [ɪ$_1$-ay] vs. [ɪ$_1$-iy], where $\chi^2<1.0$), the difference is not impressive in [iy] (the only significant difference in the [iy-ɛ] pattern is [ɛ$_1$-iy] vs. [ɛ$_1$-ey], where $\chi^2=5.82$, $p<.05$).

Past Formation

There were 55 subjects who took part in the past formation task. Of the total 1430 responses, there were 9 null responses. These include 3 null responses in [ɔy], 2 in [ey], 1 each in [ay], [iy], [uw], and [ɛ]. In making responses, the subjects tended to added [-t], [-d] or [-əd] to the end of the past forms. Since we are only interested in observing how the vowels may change, such additions were ignored as long as the subject changed the vowel in the derived forms. However, this behavior of adding the regular past tense suffixes also indicates that the semantics of "pastness" was important in the task. Table 3.12 shows the frequencies of responses in this task. As in the nominalization task, Tables 3.13 and 3.14 show 26-item frequencies, and frequencies of subjects making consistent responses, respectively.

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[4] Of these four tense vowel categories, [ow] is not shown in Table 3.11 because its VS and NVS variants coincide.

In Table 3.13, we see quite a few switches of high frequencies in each vowel category. As a matter of fact, in the 13 vowel categories, there were only 6 consistent high frequencies between items. Three of the six were with [æ] as the object vowel — [ɪ-æ], [ʊ-æ], and [ʌ-æ]. The other three were [uw-ɔ], [æ-ey] and [ɔ-ow]. Thus it seems that there was a much greater inter-item variation in this task than in the nominalization task.

As in the nominalization task, the number of inconsistent responses in Table 3.14 is also great (438, or 61%). Comparing Table 3.14 with Table 3.12, we find that the high frequency profiles are identical except in the [aw] row, where the vowel was associated most frequently with [ow] in Table 3.12, but with [ɔ] in Table 3.14.

Table 3.12 Response Frequencies for Past Formation Task Group. (Underlined cells are highest frequencies among source vowels (rows). Starred cells are highest among the object vowel categories (columns). Frequencies of 9 or lower are insignificant. Italicized cells are VS responses. N=55.)

	Response Vowel												
Source Vowel	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay	0	20	10	5	16	11	_12_*	3	14	1	11	3	3
ey	6	0	11*	4	23	3	6	4	_19_	2	21	8	1
iy	9	19	0	4	34*	1	0	_10_	19	0	8	6	0
aw	5	7	5	0	18	12	6	12*	13	4	13	_12_	2
ow	3	8	11	4	0	22*	3	2	19	1	_21_	16*	0
uw	1	10	8	12*	15	0	5	6	16	0	_28_*	_8_	0
ɪ	_6_	11	2	1	7	1	0	1	51*	0	19	11	0
ɛ	2	9	_9_	5	12	7	7	0	30	0	23	5	0
æ	2	_33_*	7	0	19	6	7	8	0	0	18	10	0
ʊ	4	9	2	3	16	5	6	9	27	0	21	7	1
ɔ	3	17	4	1	_24_	_8_	11	10	20	0	0	12	0
ʌ	3	7	4	_3_	17	_15_	4	7	37	3	10	0	_0_
ɔy	4	9	8	3	16	18	5	3	18	2	14	_7_	0
TOTAL	48	159	81	45	217	109	72	75	283	13	207	105	7

Thus although Table 3.12 shows quite a reliable picture of intra-subject performances, the inter-item variations are not clear at all. Looking at the total frequencies of the response vowels, it seems that the object-oriented strategy had some significance. The fact that [æ] and [ow] are the most preferred vowels seems to provide some evidence of something like the lowering ablaut rule (for vowels to become low in past forms, as in *sing-sang*) and the backing ablaut rule (for vowels to become back in past forms, as in *steal-stole*) discussed in Halle and Mohanan (1985). However, unlike what was suggested by Halle and Mohanan, these ablaut rules look more object-oriented than

Table 3.13 Frequencies of Responses to Individual Items in the Past Formation Task. (High frequencies in each source vowel category are underlined and VS response cells are italicized. R_1 and R_2 are totals for the first and second replications, respectively.)

	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay$_1$	0	9	6	3	9	1	*4*	1	9	0	9	3	1
ay$_2$	0	11	4	2	7	10	*8*	2	5	1	2	0	2
ey$_1$	4	0	3	4	15	1	3	2	*7*	2	9	3	1
ey$_2$	2	0	8	0	8	2	3	2	*12*	0	12	5	0
iy$_1$	2	9	0	3	6	1	0	*9*	14	0	8	3	0
iy$_1$	7	10	0	1	28	0	0	*1*	5	0	0	3	0
aw$_1$	2	4	1	0	12	6	5	6	6	0	6	*5*	1
aw$_2$	3	3	4	0	6	6	1	6	7	4	7	*7*	1
ow$_1$	1	5	6	2	0	10	2	1	10	1	*15*	2	0
ow$_2$	2	3	5	2	0	12	1	1	9	0	*6*	14	0
uw$_1$	0	5	4	7	5	0	3	1	12	0	*15*	*2*	0
uw$_2$	1	5	4	5	10	0	2	5	4	0	*13*	*6*	0
ɪ$_1$	*3*	4	1	0	2	1	0	0	25	0	11	8	0
ɪ$_2$	*3*	7	1	1	5	0	0	1	26	0	8	3	0
ɛ$_1$	1	3	*4*	3	5	3	5	0	18	0	10	3	0
ɛ$_2$	1	6	*5*	2	7	4	2	0	12	0	13	2	0
æ$_1$	2	*20*	2	0	10	4	2	5	0	0	5	5	0
æ$_2$	0	*13*	5	0	9	2	5	3	0	0	13	5	0
ʊ$_1$	2	4	0	0	7	2	5	6	14	0	11	4	0
ʊ$_2$	2	5	2	3	9	3	1	3	13	0	10	3	1
ɔ$_1$	1	5	2	1	*12*	*4*	6	4	11	0	0	9	0
ɔ$_2$	2	12	2	0	*12*	*4*	5	6	9	0	0	3	0
ʌ$_1$	0	2	3	*1*	15	*4*	2	2	17	2	7	0	*0*
ʌ$_2$	3	5	1	*2*	2	*11*	2	5	20	1	3	0	*0*
ɔy$_1$	2	7	1	2	6	7	3	3	10	2	8	*3*	0
ɔy$_2$	2	2	7	1	10	11	2	0	8	0	6	*4*	0
R$_1$	20	77	33	26	104	44	40	40	153	7	114	50	3
R$_2$	28	82	48	19	113	65	32	35	130	6	93	55	4
TOTAL	48	159	81	45	217	109	72	75	283	13	207	105	7

Table 3.14 Number of Subjects Making Consistent Responses to Each Vowel Category in Past Formation Task. (Underlined cells are highest within the source vowel category and italicized ones correspond to VS responses.)

Source Vowel	Response Vowel												
	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay	0	3	2	1	3	0	*2*	0	2	0	1	0	0
ey	1	0	3	0	6	0	0	1	*3*	0	4	2	0
iy	1	3	0	1	5	0	0	*0*	3	0	0	1	0
aw	2	0	1	0	3	1	0	1	3	0	4	*2*	0
ow	1	0	1	1	0	5	1	0	3	0	*5*	2	0
uw	0	1	1	2	2	0	1	0	4	0	*8*	*1*	0
ɪ	*1*	3	1	0	1	0	0	0	21	0	4	1	0
ɛ	0	2	*0*	0	2	2	1	0	9	0	6	1	0
æ	0	*9*	1	0	4	1	0	1	0	0	4	4	0
ʊ	2	2	0	0	4	0	0	1	8	0	7	1	0
ɔ	1	4	1	0	*7*	*2*	3	2	4	0	0	1	0
ʌ	0	1	0	*0*	2	*1*	1	1	12	1	3	0	*0*
ɔy	1	1	1	1	4	5	0	0	4	0	4	*1*	0
TOTAL	10	29	12	6	43	17	9	7	76	1	50	17	0

source-oriented. This point is clear when we see that in the [æ] and [ow] columns in Tables 3.12 and 3.13, the source vowels that contributed to these categories were quite dispersed. It would be very difficult to characterize the environment for these ablaut rules in terms of the source vowels. It is also not promising to attempt to characterize these source-oriented vowel changes in terms of VS alternations. Although there were three consistent inter-item VS frequencies ([uw-ɔ], [æ-ey], [ɔ-ow], see Table 3.13; these were also the only high VS frequencies in Table 3.12), the responses were generally quite haphazard in terms of the source-oriented strategy. There was also nothing approaching the reverse pattern strategies apparent in the nominalization task. For example, while the [æ-ey] pattern was strong, the [ey-æ] pattern was not, despite the fact that [æ] was the most preferred object vowel.

We also made an attempt to explain the source of the preferred vowel patterns. Table 3.15 lists the Test response frequencies, Type frequencies and Token frequencies for the relevant English irregular past forms based on the data to be found in Appendix V. A rank order correlation test showed that the Test-Type correlation was significant (Kendall's tau-*b*=.37, one-tailed $p<.05$); however, the correlation between Test frequencies and Token frequencies was not significant (tau-*b*=.25, one-tailed $p>.10$). One possible reason why the Test-Token correlation was so low is because of the large number of invariant present-past relationships, i.e., in which no vowel change occurs. Thus another correlation analysis was done with the frequencies of these invariant forms removed. These results did not give us a much clearer insight into what was really happening either, however. For the Test-Type correlation, Kendall's tau-*b*=.34, one-tailed $p>.05$; for the Test-Token correlation, tau-*b*=.33, one-tailed $p>.05$. So the token frequencies did not seem to have influenced subjects' performances in this task in any significant way.

Notice that most of these irregular verbs are highly frequent ones. It is possible that the frequency of occurrence of a word does not have much of an effect on speakers once it has gone beyond a certain threshold level.

Table 3.15 Frequencies of Response Vowels in Past Formation Contrasted with Type and Token Frequencies of English Past Forms with Vowel Changes. (Frequencies in parentheses are those after invariant forms are removed.)

	æ	ow	ɔ	ey	uw	ʌ	iy
Test	283	217	207	159	109	105	81
Type	17 (14)	19	21 (20)	6	9	18 (15)	1 (0)
Token	6174 (5936)	6188	14381 (13771)	9344	4257	4049 (1877)	540 (0)

	ɛ	ɪ	ay	aw	ʊ	ɔy
Test	75	72	48	45	13	7
Type	33 (27)	15 (7)	0	4	11 (10)	0
Token	35055 (28119)	9633 (8246)	0	5204	8461 (4519)	0

Therefore we can conclude that the performances of the past formation task were mostly influenced by the "Type" frequency pattern of English verbs. As the subjects' performances were primarily object-oriented, there is no interesting VS activities to be observed in this task.

The object vowel orientation in Table 3.12 did not give us a clearer picture of VS activities either. Three high VS frequencies emerged in the object vowel count ([ay-ɪ], [uw-ɔ], [æ-ey]), of which the latter two also showed up in the source-to-object count. The [ay-ɪ] alternation was weak: it emerged as highest only in the object vowel count, and even here the figure was not impressive (12). Thus with either count there are only four high VS frequencies altogether: [ay-ɪ], [uw-ɔ], [æ-ey] and [ɔ-ow]. As we can see, these patterns are quite dispersed, and unlike the NOM task, each pattern only occurred once, that is, either tense to lax or lax to tense. Judging from the performances of the VS patterns, we have reasons to expect that, if two vowels are actively linked, then the strength of the link out to be preserved in both directions. Since this expection was not borne out in this task, it seems fair to conclude that VS activity in past formation is minimal.

Pluralization Task

There were 54 subjects in the pluralization task group. In making responses, the subjects tended to suffixate [-s], [-z] or [-əz] to the derived forms. As in the preceding task, the suffixing was ignored as long as the response met the requirement of changing the vowel.

Table 3.16 shows the response frequencies in this task. The most striking point is that almost half of the responses (48.6%) had [iy] as the response vowel. As a matter of fact, some subjects seemed to feel they were making too many [iy] responses, and at some point deliberately responded with other vowels to provide some variation. With this overwhelming tendency to use [iy] as the object vowel, we can expect that there was not much intra-subject and inter-item variations. This expectation was confirmed when we break up the response frequencies into a 26-item table

Table 3.16 Response Frequencies for Pluralization Task Group. (Underlined cells are highest frequencies among source vowels (rows). Starred cells are highest among the object vowel categories (columns). Frequencies of 9 or lower are insignificant. Italicized cells are VS responses. N=54.)

Source Vowel	Response Vowel												
	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay	0	13	54	13*	5	6	_10_*	1	1	0	1	0	4
ey	20	0	63	2	2	3	4	6	_6_	0	2	0	0
iy	32*	6	0	7	15*	6	4	_26_*	4	0	4	2	0
aw	26	6	51	0	2	8	3	3	3	0	1	_1_	3
ow	16	4	64	4	0	6	1	0	3	0	_6_	4	0
uw	10	3	73*	7	3	0	1	3	3	1	_0_	_2_	2
ɪ	_25_	3	37	2	1	2	0	7	14*	0	14*	2	1
ɛ	7	5	_59_	3	9	0	7	0	7	0	10	0	1
æ	10	_23_*	48	1	2	1	4	15	0	0	2	0	2
ʊ	16	2	60	3	4	6	4	4	3	0	1	3	2
ɔ	10	8	60	2	_15_*	_4_	2	3	3	0	0	1	0
ʌ	21	4	57	_2_	8	_5_	2	2	4	2	1	0	_0_
ɔy	21	5	56	6	5	0	6	1	6	0	2	_0_	0
TOTAL	214	82	682	52	71	47	48	71	57	3	44	15	15

(Table 3.17), and when we look at only those cases where the subjects responded consistently to a particular vowel (Table 3.18).

It is also worthy of note that when [iy] was the source vowel, and the subject was asked to change it to some other vowel, the majority of responses went to the second most preferred vowel [ay]. But looking at Table 3.14, the [iy-ɛ] response frequency was quite close to that of [iy-ay]. Tables 3.17 and 3.18 also reflect this. In Table 3.17 where the two items with the same source vowel are distinguished, [ɛ] was the most frequently used vowel with [fiyn] (iy,) as the source form, but [ay] was the most frequently used vowel

Table 3.17 Frequencies of Responses to Individual Items in the Pluralization Task. (High frequencies in each source vowel category are underlined, and VS response cells are italicized. R$_1$ and R$_2$ are totals for the first and second replications, respectively.)

	ay	ey	iy	aw	ow	uw	ɪ	ɛ	æ	ʊ	ɔ	ʌ	ɔy
ay$_1$	0	4	32	10	2	1	*1*	1	1	0	1	0	1
ay$_2$	0	9	22	3	3	5	*9*	0	0	0	0	0	3
ey$_1$	13	0	34	1	2	2	0	0	*2*	0	0	0	0
ey$_2$	7	0	29	1	0	1	4	6	*4*	0	2	0	0
iy$_1$	13	3	0	5	5	3	2	*16*	1	0	4	0	0
iy$_2$	19	3	0	2	10	3	2	*10*	3	0	0	2	0
aw$_1$	11	3	28	0	0	4	2	2	0	0	0	*1*	2
aw$_2$	15	3	23	0	2	4	1	1	3	0	1	*0*	1
ow$_1$	6	2	34	3	0	2	0	0	1	0	*6*	0	0
ow$_2$	10	2	30	1	0	4	1	0	2	0	*0*	4	0
uw$_1$	5	1	38	5	1	0	0	2	1	0	*0*	*0*	1
uw$_2$	5	2	35	2	2	0	1	1	2	1	*0*	*2*	1
ɪ$_1$	*8*	3	16	1	1	2	0	4	7	0	10	1	1
ɪ$_2$	*17*	0	21	1	0	0	0	3	7	0	4	1	0
ɛ$_1$	3	2	*32*	1	2	0	4	0	3	0	6	0	1
ɛ$_2$	4	3	*27*	2	7	0	3	0	4	0	4	0	0
æ$_1$	8	*14*	21	1	1	0	1	7	0	0	0	0	1
æ$_2$	2	*9*	27	0	1	1	3	8	0	0	2	0	1
ʊ$_1$	10	1	27	1	2	3	1	3	2	0	1	2	1
ʊ$_2$	6	1	33	2	2	3	3	1	1	0	0	1	1
ɔ$_1$	4	3	28	1	*8*	*3*	1	3	2	0	0	1	0
ɔ$_2$	6	5	32	1	*7*	*1*	1	0	1	0	0	0	0
ʌ$_1$	7	1	28	*0*	6	*2*	2	1	4	2	1	0	*0*
ʌ$_2$	14	3	29	*2*	2	*3*	0	1	0	0	0	0	*0*
ɔy$_1$	8	2	30	3	2	0	5	1	1	0	2	*0*	0
ɔy$_2$	13	3	26	3	3	0	1	0	5	0	0	*0*	0
R$_1$	96	39	348	32	32	22	19	40	25	2	31	5	8
R$_2$	118	43	334	20	39	25	29	31	32	1	13	10	7
TOTAL	214	82	682	52	71	47	48	71	57	3	44	15	15

Table 3.18 Number of Subjects Making Consistent Responses to Each Vowel Category in Pluralization Task. (Underlined cells are highest within the source vowel category and italicized ones correspond to VS responses.)

Source	Response Vowel												
Vowel	ay	ey	iy	aw	ow	uw	ɪ	ε	æ	ʊ	ɔ	ʌ	ɔy
ay	0	0	15	3	1	0	*1*	0	0	0	0	0	0
ey	5	0	24	1	0	1	0	0	*0*	0	0	0	0
iy	8	2	0	0	2	1	1	*8*	0	0	0	0	0
aw	6	3	17	0	0	2	1	1	0	0	0	*0*	1
ow	3	1	24	0	0	0	0	0	0	0	*0*	0	0
uw	1	1	29	2	0	0	0	1	0	0	*0*	*0*	0
ɪ	*4*	0	9	1	0	0	0	0	2	0	2	0	0
ε	0	1	22	1	2	0	2	0	1	0	3	0	0
æ	2	*3*	15	0	0	0	0	2	0	0	0	0	0
ʊ	2	1	23	0	1	0	0	0	1	0	0	0	0
ɔ	0	1	20	0	*1*	*1*	0	0	0	0	0	0	0
ʌ	1	0	18	*0*	0	*0*	0	0	0	0	0	0	*0*
ɔy	6	1	22	3	1	0	0	0	0	0	0	*0*	0
TOTAL	38	14	238	11	8	5	5	12	4	0	5	0	1

for [diyv] (iy_2). As Table 3.18 shows, the same number of subjects responded consistently to [fiyn] and [diyv] with [ε] as with [ay] (n=8). Thus it seems as though the [iy-ε] alternation had some strength in this task independent of the (second-place) object popularity of [ay]. This is the only VS pattern observable in this environment, however, presumably because [iy] was not allowed in the response (due to the requirement that the source vowel must be changed). In other cases, where [iy] was allowed as a response vowel, all other possible alternation patterns were simply too weak to show up.

In the object vowel orientation, four VS frequencies emerged as the highest. They are [ay-ɪ], [iy-ε], [æ-ey] and [ɔ-ow]. The results for [ay-ɪ] and [ɔ-ow] are not particularly interesting, because they are not impressively high ([ay-ɪ] cell is only 1 point above random choice, and [ɔ-ow] is tied with [iy-ow]). The frequency of [æ-ey] is quite high, but its tense-lax counterpart, [ey-æ], is not significant (only 6). Thus we are left with [iy-ɛ]. The reverse pattern of [iy-ɛ] is [ɛ-iy], highest in the [ɛ] source vowel category. Therefore it seems that [iy-ɛ], although quite weak in NOM task, is the only VS pattern that has demonstrated strength in the PLUR task.

The source of the "plural" sense associated with [iy] is not clear, as the word frequency data are not enlightening. Table 3.19 shows the Test frequencies contrasted with Type and Token frequencies of English irregular nouns, based on the list of English irregular nouns that can be found in Appendix VI. However, as we can see, the Type frequencies are too low to be of any interest. There are only three nouns in English which use [iy] to express the plural meaning (*teeth*, *geese*, *feet*). Even if we include invariant forms like *sheep*, *Chinese*, *Japanese*, the number is only around a dozen. Furthermore, [iy] is not the highest either in Type or in Token frequencies. Because these frequencies are not comparable with the overwhelming response frequency of [iy], no correlation analysis was deemed necessary.

Though the source of the "plural" sense of [iy] is a mystery, its behavior is actually not unique to this study.

Table 3.19 Frequencies of Response Vowels in Pluralization Contrasted with Type and Token Frequencies of English Plural Forms with Vowel Changes.

	iy	ay	ey	ɛ	ow	æ	aw	ɪ	uw	ɔ	ɔy	ʌ	ʊ
Test	682	214	82	71	71	57	52	48	47	44	15	15	3
Type	4	3	1	2	0	1	3	5	1	0	1	1	0
Token	3639	255	0	4098	0	210	82	5100	63	0	16	241	0

Many people jokingly use the form [miys] as the plural for *moose*, and the fact that some people regard *people* as the plural form of *person* may also be related to the presence of the vowel [iy] in this form (cf. Householder, 1971, p. 71).

Suffice it to say that the "information load" carried by the [iy] vowel in this task is great, and we should conclude that the PLUR performance was very strongly object-oriented. No VS activities were found to be of any significance except when [iy] was disallowed as an object vowel, leaving some residual possibility for the VS associations to manifest themselves.

3.2.4 Discussion

From this experiment, we see that the preferred vowel alternations varied considerably as a function of task differences. The most prominent strategy the subjects used was the object-oriented type of vowel modification. Among the preferred vowels in the three tasks, subjects preferred [ɔ] and [ɪ] in the NOM task; [æ] and [ow] in the PAST task; and [iy] and [ay] in the PLUR task. What is interesting to note is that *none* of these preferred categories overlap across the three tasks. This suggests that the subjects had quite distinct feelings for the vowels in different situations. Therefore the vowel alternation phenomenon as demonstrated in the results of this experiment is largely morphologically conditioned, and the activities of the VS alternations are mostly limited to the NOM task. Thus it seems that the VS rule is not as "pivotal" a phonological process as Chomsky and Halle claimed it to be. It is, at best, a minor rule that should be specifically marked for its application (cf. Krohn, 1972b).

However, the results of the PAST task differ from those reported in Bybee and Slobin (1982), where [ʌ] was found to be the most preferable in the "past" environment. The reason for the difference is not clear. One may suggest that it is because of the effect the post-vocalic consonants have on the vowels. Bybee and Slobin's schema states that [ʌ] is typical before [ŋ]. Because of the phonotactic reason that no tense vowel is possible before [ŋ], we did not choose to use [ŋ] in post-vocalic positions in order to allow for a full range of possible responses. But we did have several items which bear family resemblances to [ŋ] (according to Bybee and Slobin). *These are [n], [g] and [k]* in [fiyn] (iy$_1$ in Table 3.13), [slɔn] (ɔ$_1$), [hɪg] (ɪ$_1$), [fɔyg] (ɔy$_1$), [nawk] (aw$_2$) and [nʊk] (U$_1$) (see Appendix II). There the [ʌ] response frequencies were 3, 9, 8, 3, 7, 4 respectively. Except for [nʌk] (←[nawk]), which was the highest in the source-to-object count (tied with [næk] and [nɔk]), none of the others were the highest in the category. In the object vowel orientation, [nʌf] (←[nowf], ow$_2$) was the highest. The [ʌ] before [f] was not predicted by Bybee and Slobin's theory. Therefore the difference betwen the two studies remains a mystery.

The NOM task demonstrated the most VS activities. The reason, I suspect, is probably because although speakers have some awareness of what a good *-ity* form should be (Armbruster's experiments IV and V), the feeling may not be as strong as the feelings for plurals and past forms. That is, [iy] and [ay] gave the subjects strong "plural" feelings; and [æ] and [ow] gave the subjects strong "past" feelings. Perhaps in some (learned) sound symbolic sense, these vowels suggest these meanings. Notice that while the past formation and pluralization processes brought about major semantic changes but not changes in form classes, the nominalization process brought about changes in form classes but not in meaning. That is to say, the sound symbolism in this study, if any, was probably more associated with meanings than with form classes. For *-ity* forms, the well-formedness feeling was probably only phonological —

the more prominent vowels were all lax before *-ity*. Because *-ity* already suggests a noun form, it is possible that the subjects did not feel compelled to make the form sound more like a noun with the vowel. Whether this speculation has any validity should be subject to empirical investigation. Because only the NOM task produced interesting VS responses, our ensuing discussions of the production test are centered around this part.

As we have demonstrated, the four VS patterns [ay-ɪ], [ey-æ], [iy-ɛ] and [ow-ɔ] showed up quite clearly in the NOM task. Of the other VS patterns predicted by the theories, only [uw-ɔ] exhibited strength in the tense to lax modification. But this pair is only predicted by the SPE model. Of the alternations proclaimed in the 1977 and 1985 models, except for the first four pairs above, none of the others ([aw-ʌ], [uw-ʌ], [ɔy-ʌ]) showed up. We have commented in section 2.3 about the unreality of [aw-ʌ]. Our results in the production test reconfirmed that [aw-ʌ], though a pivotal component in a "shift" theory of vowel alternations, is an outcast. When [aw] and [ɔy] were the source vowels, the majority of responses went to [ɔ]. The [aw-ɔ] and [ɔy-ɔ] alternations are obviously not characterizable by vowel shift, because the vowel neuclei involved in these alternations are all [+low]. However, it is quite surprising that the [uw-ʌ] alternation, which Jaeger found to be real in her concept formation test, did not show any strength in our production experiment. It is surmised here that while [uw-ʌ] is an orthography-based rule, as suggested by Jaeger, it has not quite been phonologized. We will discuss this point more fully in Chapter 4.

3.3 Concept Formation Test

Jaeger (1980) used a concept formation technique to test whether the vowel alternation phenomenon is a phonological rule or a spelling-based rule. She argued for the latter from the results of her experiment. But as mentioned earlier, since Halle (1977) incorporated the [uw-ʌ] alternation in the system of vowel shift, Jaeger's argument was weakened by the modification of the theory. In the present study, we used a similar technique to Jaeger's, but for a slightly different purpose. As in Jaeger's study, we trained the subject to respond to the word pairs according to some rule, and then in the test session we observed how the subject performed in the test items on the basis of that. However, the items we tested had the tense vowels [aw, uw, ɔy] as the first members, and the lax vowels [ɔ,ʌ] as the second members. These combinations are shown as follows:

1. [aw-ɔ], as in *astound-astonish*
2. [aw-ʌ], as in *pronounce-pronunciation*
3. [uw-ɔ], as in *fool-folly*
4. [uw-ʌ], as in *reduce-reduction*
5. [ɔy-ɔ], as in *joy-jolly*

6. [ɔy-ʌ], as in *destroy-destruction*

Since in the back vowel series, [U] does not participate in the alternations, and the three tense vowels have been alluded to in the three versions of vowel shift rule, these are the possible combinations of the tense-lax pairs. The purpose of this study was to decide, first, which pairs are included in the vowel alternation phenomenon, and second, what strategies are used by the subjects, and hence how the phenomenon can be more realistically described.

3.3.1 Subjects

Seventy-two high school students were recruited from their second language classes. They were all 11th and 12th graders and took part in the experiment on a voluntary basis.

3.3.2 Material

Two experimental conditions were designed. In the first condition, the subject was taught to form the vowel-shift (VS) rule according to the four alternations all uncontroversially accepted as part of the vowel shift phenomenon: [ay-ɪ], [ey-æ], [iy-ɛ] and [ow-ɔ]. In the second condition, the subject was taught to form the anti-vowel-shift (AVS) rule based on four alternations involving the same tense vowels as the vowel shift group: [ay-ɛ], [ey-ɪ], [iy-æ], and [ow-ʌ]. In the instructions of the test, the subject was asked to discover a particular relationship between the vowels in the pairs of words. They were asked to say "YES" to those pairs which bear this relationship, and "NO" to others.

The learning phase comprised 64 pairs of words, half of which were positive (VS or AVS) tokens and half negative (control) tokens. Of these positive and negative tokens, half of them were real English words, and half of them were nonsense words. The real words involved a variety of morphological relationships, while the nonsense words all assumed the shape of adjective-noun (*-ity*). These nonsense forms were mostly taken from Cena's (1976) study and our own production test. They were also offered to native speakers of English in the Department of Linguistics for well-formedness judgements, and care was also taken to minimize possible associations between these nonsense forms and real English words.

In the test phase, 16 positive and 10 negative pairs of the same type as in the learning phase were used as reinforcements of the concept learned. As in the learning phase, half of these reinforcement tokens were real English words and half were nonsense words. In addition to these reinforcement items, there were 18 test items with patterns shown in section 3.3. These items were the same for both groups. Of the three pairs in each type of the test items, two were real words, and one was a nonsense word which was, again, of the adjective-noun (*-ity*) form. The stimuli in both groups were randomized separately. Care was taken to make sure that pairs of the same alternating pattern were at least two items apart. In both test conditions there was one order of presentation in the learning phase and two orders of presentation in the test phase. Each of the two orders in the test phase was the reverse of the other. (These procedures are summarized in Table 3.20, and the complete instructions and lists of stimuli appear in Appendix VII.)

3.3.3 Procedure

The instructions and presentations were read into cassette tapes by a female native speaker of Canadian English. Each pair was read twice. After a pause of three seconds, a "YES" or "NO" was recorded on the tape to indicate whether the pair was an example of the alternation patterns. The subjects were instructed to respond during the three-second pause and before the "YES" or "NO" cue they would hear from the tape, and check their answers against the cue. In the test phase, 10 of the reinforcement items and all of the test items had a "beep" sound in place of the "YES" or "NO" on the tape. The subjects continued to respond during the three-second pause.

The actual testing was done in a high school language laboratory. The master tapes were made into 72 copies such that the subjects listened to their own tapes. In this way the experimenter could test the subjects in any number that

Table 3.20 Procedures for the Concept Formation Test

I. Instructions:

(The subject was asked to find out a particular vowel-change relationship in the word pairs he/she was going to hear in the tape. In each item the presentation was with the format:

1st presentation	2nd presentation	3 sec. pause	"YES" or "NO"	2 sec. pause
		↑ YOU RESPOND HERE		

In the test phase, some of the reinforcement items and all of the test items had "beeps" to replace the "YES" or "NO".)

A. VS Condition		B. AVS Condition	
II. Learning Phase (64 items)			
divine-divinity	"YES"	peace-pacify	"YES"
profane-profanity	"YES"	lame-limp	"YES"
receive-receptive	"YES"	die-dead	"YES"
cone-conical	"YES"	solar-sun	"YES"
mind-mental	"NO"	find-found	"NO"
peace-pacify	"NO"	vacant-vacuous	"NO"
false-fallacy	"NO"	steal-stolen	"NO"
propel-propulsion	"NO"	pope-papal	"NO"
III. Test Phase (44 items)			
Reinforcement Items (26 items)			
malign-malignant	"YES"	clear-clarity	"YES"
nature-natural	(beep)	equate-equivalent	(beep)
sustain-sustention	"NO"	law-legal	"NO"
clear-clarify	(beep)	receive-receptive	(beep)

Test Items (18 items)

[aw-ɔ]	astound-astonish
[aw-ʌ]	profound-profundity
[uw-ɔ]	fool-folly
[uw-ʌ]	reduce-reduction
[ɔy-ɔ]	joy-jolly
[ɔy-ʌ]	destroy-destruction

was available at one time. The subjects sat in separate seats in the lab, each facing a recorder and an instruction sheet. They were told to start the tape and read the instructions along with the tape through the headphone. The subjects could stop the tape and ask questions. After finishing the instructions, the subjects were told if they did not have questions, they could go on to the experiment. At this time, the subjects were told to record their answers on the tape, and to avoid rewinding. The subjects listened to the stimuli from one track of the cassette tape and recorded their answers on another track, until they were was finished with the entire 108 items. Then a voice on the tape told the subject to answer the question printed at the bottom of the instruction sheet:

> "Did you figure out what the relationship is between the vowel pairs? Can you describe in a few words the nature of the relationship?"

The subjects were asked to write their answers to the above questions on the instruction sheet.

The experimenter then collected the tape, and listened and recorded the responses. In this way the experimenter could make sure that the subject responded before the "YES"/"NO" cues.

3.3.4 Results

Of the 72 subjects, two obviously misunderstood the instructions and responded *after* the "YES"/"NO" cues. One of them worked on the VS concept, the other on the AVS concept. There was also one subject in the AVS group who gave up after the 14th item. The data obtained from these three subjects were therefore discarded. Due to mishandling of the lab equipment, some (3 to 6) items in the beginning part of the learning phase were accidentally erased on nine of the tapes. Six of the tapes had the VS task, and three the AVS task. The bulk of the data from these subjects were not affected and were retained.

Criterion was set at 10 error-free trials in a row at any point in the learning phase. If a subject reached this criterion, it was assumed that the subject had successfully formed the required concept and was able to follow the rule in making the responses. Any mistake made after that point was considered a performance error.

In the VS group, 25 of the 35 subjects reached criterion. The average number of trials before reaching criterion was 28 (range 0-51, s.d.=15.63). The data from these 25 subjects are included in the analyses that follow.

Table 3.21 shows the frequencies and proportions of responses to *positive tokens* in the learning phase.[5] From the proportions we see that the [ay-ɪ] alternation was the easiest to learn, while [ey-æ] was the hardest. However, a two-factorial ANOVA did not show a significant main effect

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[5] Five of the subjects who reached criterion had tapes with some of the items in the learning phases erased. In order not to bias the scores in either direction, these five subjects' data were excluded from the results shown in Table 3.21.

Table 3.21 Frequencies and Proportions of Responses by 20 VS Subjects in the Learning Phase

Alternation Type	Response Type		
	"YES"	"NO"	Null
[ay-ɪ]	143(.89)	14(.09)	1
[ey-æ]	124(.78)	33(.21)	3
[iy-ɛ]	136(.85)	23(.14)	0
[ow-ɔ]	131(.82)	29(.18)	0
Total	534(.83)	99(.15)	4
NEG Token	130(.20)	503(.79)	6

for alternation types ($F(3,152)=2.35$, $p>.05$). The word type (real vs. nonsense) effect was also not significant ($F(1,152)=0.33$, $p>.10$). The interaction between alternation patterns and word types, however, was significant ($F(3,152)=4.25$, $p<.01$). This interaction effect was caused by the [ow-ɔ] alternation, where subjects scored 93% on nonsense pairs but only 71% on real pairs, whereas on other patterns the real pairs were scored consistently higher than the nonsense pairs. The reason for this difference is probably because of the difference in the grammatical relatedness of the pairs. In a separate judgement test, 59 university students were asked to judge the relatedness of the word pairs. (See Appendix X for the test pairs and the subjects' ratings.) The mean ratings of the 16 pairs used in the learning phase were contrasted with the success rates for these items in this judgement test. The correlation coefficient was very high ($r=.81$) and the correlation was significantly different from zero ($t(14)=5.17$, $p<.001$). An independent t-test comparing the mean ratings of the [ow-ɔ] pairs and those of the other three patterns also showed great significance ($t(14)=5.67$, $p<.001$). The four [ow-ɔ] pairs used in the learning phase of the concept formation experiment were *joke-jocular* (2.85), *code-codify* (3.85), *provoke-provocative* (4.27), and *ferocious-ferocity* (3.89). The numbers in parentheses are the mean values given in the relatedness judgement test (out of a maximum of 5.00).

In the test phase, the picture was quite different. While [ey-æ] showed the greatest difficulty in the learning phase, [iy-ɛ] caused more errors than other reinforced patterns in the test phase. The frequencies and percentages of responses in this part are shown in Table 3.22.[4]

A factorial ANOVA test on the percent correct points the individual subject scored in each pattern showed that the difference among the means was great ($F(3,192)=10.90$, $p<.01$). A Scheffé test comparing the differences among these means showed that the [iy-ɛ] response frequency was significantly different from those of the other three patterns, the latter forming a homogeneous group ($\alpha=.05$). No significant difference was found between real and nonsense pairs ($F(1,192)=1.83$, $p>.10$). The interaction between word types and alternation patterns was great ($F(3,192)=4.62$, $p<.01$). This time the difference was caused

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[4] In this table, the data of all 25 subjects who reached criterion in the learning sesson were used.

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Table 3.22 Frequencies and Proportions of Responses by 25 VS Subjects in Test Phase (Reinforcement Tokens)

Alternation Type	Response Type		
	"YES"	"NO"	Null
[ay-ɪ]	94(.94)	6(.06)	0
[ey-æ]	95(.95)	5(.05)	0
[iy-ɛ]	78(.78)	22(.22)	0
[ow-ɔ]	96(.96)	3(.03)	1
Total	363(.91)	36(.09)	1
NEG Tokens	39(.16)	209(.84)	1

by the relatively low correct rate of the nonsense pairs in the [iy-ɛ] pattern (see Figure 3.1).

Upon closer examination of the responses made in [iy-ɛ] we found that the two real pairs, *receive-reception* and *obscene-obscenity*, received 19(76%) and 25(100%) positive responses, respectively; while the two nonsense pairs, *prol*[iy]*t-prol*[ɛ]*tity* and *ex*[iy]*l-ex*[ɛ]*lity* received 19(76%) and 15(60%) positive responses, respectively. If we compare the percentages of correct answers made to each positive pattern in the learning and the test phases, we find that subjects improved on all patterns except [iy-ɛ], where the performances deteriorated. This relationship is seen in Figure 3.1.

Table 3.23 shows the response patterns the subjects made to the reinforcement and test tokens in the test phase. As is evident, the results were quite similar to those of Jaeger's experiment. The rejection rate of [aw-ʌ] was

Figure 3.1 Transitions of Response Proportions from Learning to Test Phases in Each Alternation Pattern (20 subjects only).

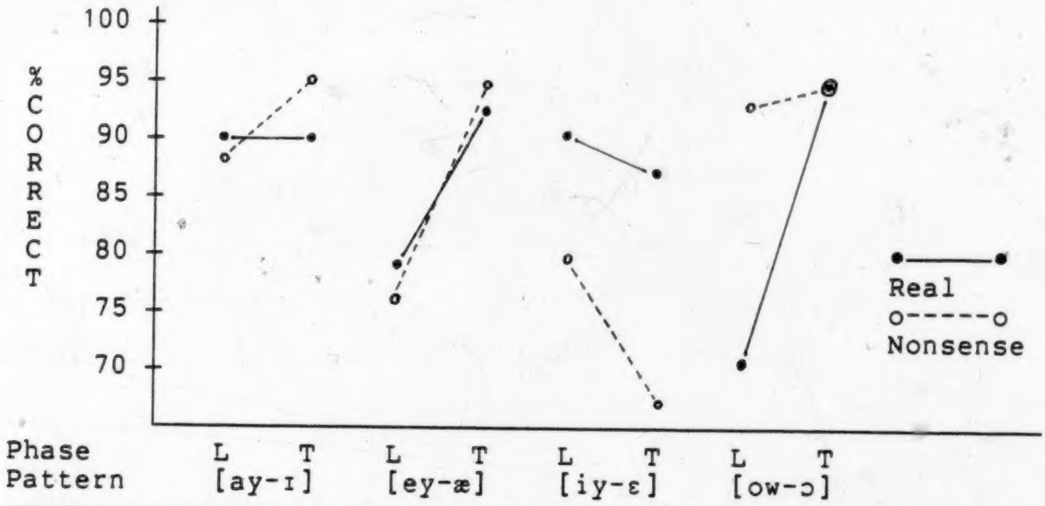

Table 3.23 Frequencies and Proportions of responses by 25 VS Subjects in Test Phase. (Figures in square brackets are corresponding proportions in Jaeger's experiment)

Alternation Type	Response Types "YES"	Response Types "NO"	Null
POS Token	363(.91)[.82]	36(.09)[.15]	1
NEG Token	39(.16)[.09]	209(.84)[.88]	2
[aw-ɔ]	30(.41)	44(.59)	1
[aw-ʌ]	18(.24)[.09]	56(.75)[.86]	1
[uw-ɔ]	44(.59)	31(.41)	0
[uw-ʌ]	58(.77)[.75]	17(.23)[.16]	0
[ɔy-ɔ]	36(.48)	29(.52)	0
[ɔy-ʌ]	11(.15)	54(.85)	0

somewhat lower in the present study, but a chi-square test on the two sets of frequencies (Jaeger's and ours) did not show significant difference ($\chi^2=3.82$, $p>.05$).[7]

The other case that replicated Jaeger's study was the [uw-ʌ] pair. The proportions of response to this pair are very similar to those in Jaeger's study, and the chi-square test on the two sets of frequencies showed that the difference was insignificant ($\chi^2=0.42$, $p>.10$).[8]

An ANOVA test (repeated measures) was performed on the percentages of individual's "YES" answers to the positive reinforcement tokens and the test patterns, and the result showed great difference among the means ($F(6,144)=21.8$, $p<.01$). Using the Dunnett's test described in Winer (1971, pp.201-04) to contrast the mean of the positive reinforcement tokens with each of the means of the test patterns, we found that all test patterns were different from the positive reinforcement tokens except [uw-ʌ] (one-tailed t-tests, $\alpha=.05$).

Similarly, an ANOVA test was performed on the percentages of "NO" answers, and the difference among the means was also great ($F(6,144)=16.3$, $p<.01$). Dunnett's tests showed that all test patterns were significantly

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[7] It should be noted that the chi-square test may not be appropriate for this purpose, as each subject had three chances to accept or reject the [aw-ʌ] pattern; that is, the experiment is a repeated-measures design. But as I do not know of any suitable statistical procedure to make the comparison, the results of the chi-square test on the frequencies are given here as the best indication we have that the differences between the two studies may not be significant.

[8] See the note above.

Table 3.24 Comparisons between Reinforcement Tokens and Test Patterns in the Test Phase of VS Task. (Dunnett's method was used. Significance levels show one-tailed probabilities. "YES" responses of the patterns were compared with those of the positive reinforcement tokens, "NO" with those of the negative tokens. *df*=144)

	"YES"	"NO"
[aw-ɔ]	*t*=5.94***	*t*=3.12**
[aw-ʌ]	*t*=7.97***	*t*=1.12
[uw-ɔ]	*t*=4.05***	*t*=5.28***
[uw-ʌ]	*t*=1.64	*t*=7.46***
[ɔy-ɔ]	*t*=5.10***	*t*=3.95**
[ɔy-ʌ]	*t*=9.28***	*t*<1.0

$*p<.05$ $**p<.01$ $***p<.001$

different from the negative reinforcement tokens except [aw-ʌ] and [ɔy-ʌ] (one-tailed *t*-tests, $\alpha=.05$). Table 3.24 presents such comparisons.

However, since ANOVA tests assume normal distribution, one may raise the question about the variability of the percentages in the above tests. Except for the reinforcement tokens, there were only three pairs to each test pattern (two real and one nonsense). Thus there were only four possible percentage scores to each cell, namely, 0, 33, 67, 100. To approach a normal distribution of the scores, the following transformation was done.

Each percentage was taken as a proportion. For each pattern, the scores of five subjects were then combined and averaged into a single score. The square root of this score was taken as the score of the case. Since there were 25 subjects, there were five cases after the transformation. With this transformation there were 16 possible scores to each cell. The same tests were performed, and the results did not differ from the above analysis. With positive tokens and "YES" answers to the test patterns, $F(6,24)=26.71$, $p<.01$. Dunnett's tests showed significant differences between the positive reinforcement tokens and each of the test patterns except [uw-ʌ] (one-tailed t-tests, $\alpha=.05$). With negative tokens and "NO" answers, $F(6,24)=10.98$, $p<.01$. Dunnett's tests showed significant differences between the negative reinforcement tokens and each of the test pattern except [aw-ʌ] and [ɔy-ʌ] (one-tailed t-tests, $\alpha=.05$).

Thus we can see that [uw-ʌ] was accepted by the subjects as equivalent to a positive reinforcement token, while [aw-ʌ] and [ɔy-ʌ] were rejected (i.e., taken to be equivalent to a negative token). The other three patterns, [aw-ɔ], [uw-ɔ] and [ɔy-ɔ] were undecided, in that they were distinct from both positive and negative tokens. In the cases where the patterns were clearly accepted or rejected, they all involved [ʌ]. In the unclear cases, they all involved [ɔ]. It thus seems reasonable to assume that the subjects were aware which vowel [ʌ] was to alternate with, and were not clear which vowel(s) [ɔ] was to associate with (apart from the original [ow]).

Table 3.25 Frequencies and Proportions of Responses by 3 AVS Subjects in Learning Phase

Alternation Type	Response Types "YES"	 "NO"	 Null
[iy-æ]	20(.83)	2(.08)	2
[ey-ɪ]	21(.88)	3(.13)	0
[ay-ɛ]	19(.79)	5(.21)	0
[ow-ʌ]	17(.71)	6(.25)	1
Total	77(.80)	16(.17)	3
NEG Token	42(.44)	51(.53)	3

Table 3.26 Frequencies and Proportions of Responses by 3 AVS Subjects in Test Phase (Reinforcement Tokens)

Alternation Type	Response Types "YES"	 "NO"	 Null
[iy-æ]	10(.83)	2(.17)	0
[ey-ɪ]	12(1.0)	0(.00)	0
[ay-ɛ]	11(.92)	1(.08)	0
[ow-ʌ]	12(1.0)	0(.00)	0
Total	45(.94)	3(.06)	0
NEG Token	17(.57)	13(.43)	0

In the anti-vowel-shift (AVS) condition, only three subjects reached criterion. Their numbers of trials before reaching criterion were 50, 45 and 45 respectively (contrasted with the mean of 28 for the 25 subjects who reached criterion on VS). Tables 3.25 and 3.26 show the performances of these three subjects with regard to the anti-vowel-shift pairs in the learning and test phases.

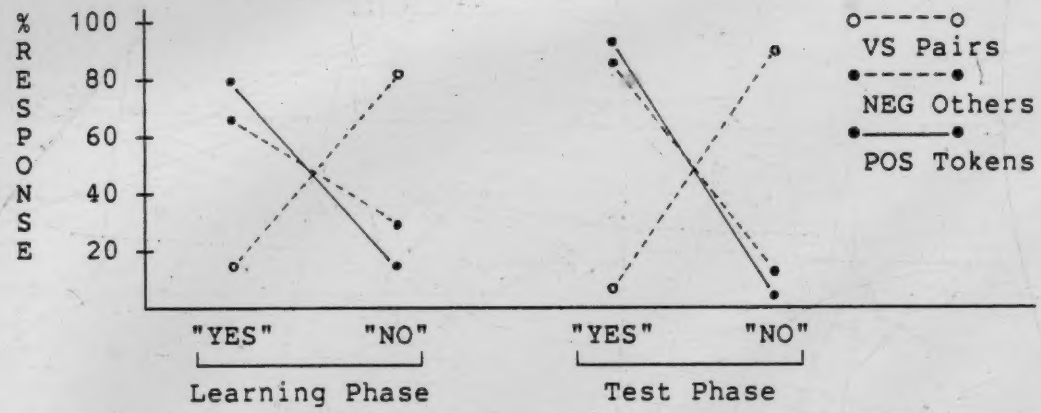
It is apparent that the three subjects had quite a high rate of success in responding to these patterns. However, it does not seem appropriate to say that they had formed the "anti-vowel-shift" concept and responded accordingly. Judging from their answers to the questions at the end of the experiment, they seemed to respond in terms of a reverse of the vowel shift pairs (or, as one subject put it, "When the same vowels used may be pronounced differently, the answer was 'no'"), and positively otherwise ("When two different vowels were used, the answer was 'yes'") (see Appendix IX for the subjects' answers). This was reflected in their responses to the negative tokens in both phases. Table 3.27 and Figure 3.2 show this profile.

In the randomized presentation, there were 8 negative tokens from items 46 to 64 (the last item in the learning phase). Of these negative tokens, 5 were of the VS type. The other 3 were items 56, 62, and 63. In other words, if the subject adopted the strategy of saying "NO" to VS pairs and "YES" to others, he/she was potentially able to reach criterion by responding correctly to items 46 through 55. As a matter of fact, two of the three who reached criterion did so in precisely this fashion. One of them correctly said "NO" to item 56, while the other said "NO" to item 62. They failed on the other two items. The third subject scored items 51 through 60, failing to reject both items 62 and 63. These facts combined explains the strategy employed by these three subjects, which was to respond negatively to

Table 3.27 Frequencies and Proportions of Responses Made to Negative Tokens by 3 AVS Subjects, Learning and Test Phases

Alternation Type	Learning Phase "YES"	Learning Phase "NO"	Test Phase "YES"	Test Phase "NO"
VS Pairs	7(.17)	34(.81)	1(.08)	11(.92)
Others	35(.65)	17(.31)	16(.89)	2(.11)

Figure 3.2 Plots of "YES" and "NO" Response Proportions of Negative Tokens (VS Pairs and Others) and Positive Tokens in AVS. Learning and Test Phases



those pairs which they felt to have natural vowel alternation relationships, and positively to others.

As to the question raised earlier about the strength of individual VS patterns, [ay-ɪ] was rejected 92% of the time by these three subjects (learning and test phases combined), [ey-æ] was rejected 73% of the time, [iy-ɛ], 80%, and [ow-ɔ], 92%. However, the differences of these percentages are not significant. Using the Cochran's *Q* test to compare

Table 3.28 Response Frequencies and Proportions of 3 AVS Subjects in Test Phase

Alternation Type		Response Type		
		"YES"	"NO"	NULL
POSITIVE		40(.94)	3(.06)	0
NEGATIVE	VS	1(.08)	11(.92)	0
	Other	16(.89)	2(.11)	0
[aw-ɔ]		0(.00)	9(1.0)	0
[aw-ʌ]		6(.67)	3(.33)	0
[uw-ɔ]		1(.11)	8(.89)	0
[uw-ʌ]		1(.11)	8(.89)	0
[ɔy-ɔ]		0(.00)	9(1.0)	0
[ɔy-ʌ]		7(.78)	2(.22)	0

the response frequencies among individual items (considering "NO" answers as correct rejections), we find Q=19.56, df=17, p>.05. This indicates that all four patterns were rejected with equal success by these three subjects.

Table 3.28 shows the response patterns of the test items made by the three subjects. Comparing Table 3.28 with 3.21, we see that for the three clear cases in the latter (i.e., [aw-ʌ], [uw-ʌ], and [ɔy-ʌ]), the response pattern was just the opposite in the former. This is what one would expect if subjects were responding negatively to VS pairs and positively otherwise. The data base is, however, very slim. To get a better picture of the viability of this hypothesis, we can try to enlarge the data base by including all those subjects who responded according to the strategy described, i.e., "NO" to VS pairs and "YES" to others. One way to do this is to examine the subjects' responses made to the negative tokens in the test phase. Each of the three

Table 3.29 Response Frequencies and Proportions of 7 AVS Subjects in Test Phase

Alternation Type		Response Type		
		"YES"	"NO"	NULL
POSITIVE		95(.85)	17(.15)	0
NEGATIVE	VS	3(.11)	25(.89)	0
	Other	36(.86)	6(.14)	0
[aw-ɔ]		4(.19)	17(.81)	0
[aw-ʌ]		13(.62)	8(.38)	0
[uw-ɔ]		8(.38)	13(.62)	0
[uw-ʌ]		3(.14)	18(.83)	0
[ɔy-ɔ]		5(.24)	16(.76)	0
[ɔy-ʌ]		15(.71)	6(.29)	0

subjects made only one deviation from the above strategy in the 10 negative tokens. If we take in those subjects who made two or fewer deviations from this strategy, we can increase our "successful" subject samples to seven. Table 3.29 shows the response patterns of these seven subjects in the test phase. Chi-square tests contrasting corresponding sets of frequencies between Table 3.28 and Table 3.29 did not show any significant difference (with Yate's correction, all $p>.10$).[1] Thus our assumption is further substantiated by the addition of four more subjects in the data.

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[1] The chi-square statistics may not be appropriate in this kind of comparison, as the frequencies in Table 3.28 are a subset of the frequencies of Table 3.29, and the experiment is a repeated-measures design. But as I do not know of any suitable statistic procedure, we will take the fact that *none* of the chi-square values in these comparisons are significant as an indication that the profiles of these two sets of frequencies are not substantially different.

However, although the clear cases in VS group were also clear in the AVS group, the unclear cases in VS group (those involving [ɔ]'s) were different. As is shown in both Tables 3.28 and 3.29, the subjects favored negative answers to all these patterns involving [ɔ]. Let us call the positive reinforcement tokens and negative tokens other than VS pairs the "non-VS" tokens, and the VS negative tokens as "VS" tokens. An ANOVA test (repeated measures) contrasting the percent "YES" responses of non-VS pairs and test patterns showed a significant F value ($F(6,36)=7.60$, $p<.001$). Using Dunnett's test to compare non-VS pairs with each of the test patterns, we found that the [aw-ʌ] and [ɔy-ʌ] were not significantly different from non-VS pairs, while the other pairs were significantly different ($\alpha=.05$)

The same methods were applied to compare the percent 'NO' responses in VS pairs and test patterns. Again the F value was significant ($F(6,36)=7.19$, $p<.001$). Dunnett's tests showed significant differences between VS and [aw-ʌ], VS and [uw-ɔ], and VS and [ɔy-ʌ]. In the other three patterns, [aw-ɔ], [uw-ʌ], [ɔy-ɔ], the results were not significantly different from VS at $\alpha=.05$ level. Table 3.30 summarizes these comparisons.[10]

Thus in all patterns involving [ɔ], the [uw-ɔ] pattern was undecided, as in the VS condition; whereas in the other two patterns, [aw-ɔ] and [ɔy-ɔ], the subjects seemed to have treated them as if they were VS alternations. But if we

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[10] Seven-subject data were used.

Table 3.30 Comparisons between Reinforcement Tokens and Test Patterns in the Test Phase of AVS Task. (Dunnett's method was used. Significance levels show one-tailed probabilities. "YES" responses of the patterns were compared with those of non-VS tokens, "NO" with those of the VS tokens. *df*=36)

	"YES"	"NO"
[aw-ɔ]	t=4.47***	t<1.0
[aw-ʌ]	t=1.57	t=3.65***
[uw-ɔ]	t=3.18**	t=1.95*
[uw-ʌ]	t=4.79***	t<1.0
[ɔy-ɔ]	t=4.14***	t<1.0
[ɔy-ʌ]	t<1.0	t=5.01***

*p<.05 **p<.01 ***p<.001

look at the general response pattern in Table 3.29, we find that the seven subjects tended to respond with "NO" to test items. Even with [aw-ʌ] and [ɔy-ʌ], the percentages for "YES" responses are considerably lower than those for "NO" responses in other patterns. One possible source of the noise is that the subjects might have tried to balance the numbers of "YES" and "NO" responses in the test phase. Observe that in the reinforcement items (top three rows in Table 3.29), the subjects made almost three times as many "YES" responses overall as "NO" responses. We cannot be certain of our interpretations until we have eliminated such possibilities.

3.3.5 Discussion

Jaeger (1980) argued for an orthographic source to the VS vowel alternation phenomenon. As mentioned in section 2.1.4.2, her claim was weakened by the 1977 version of the vowel shift rule, which incorporated the [uw-ʌ] alternation in the system. However, the concept formation test in the present study provided some further evidence for orthographic influences.

In the subjects' answers to name the vowel change relationship, many of those who reached criterion in the VS group mentioned that the change was "from a long vowel sound to a short one", and two of them specifically referred to "letters" and "spelling" (see the subjects' answers in Appendix IX). Obviously these subjects were consciously aware of the vowel alternation relationships in terms of orthography. We have also seen that the [iy-ɛ] alternation was the weakest among the reinforcement patterns. A possible source of the weak performance is the varied spellings of the [iy] phoneme. A look at the word-type frequencies reflects this. In the four vowel alternations used in the learning phase of the VS task — [ay-ɪ], [ey-æ], [iy-ɛ], [ow-ɔ] — a "long vowel" alternates with its "short" counterpart usually when it is spelled with the same single vowel letter, such as "A" in *sane*. In this case, to produce a pronounceable "short" variant one need not make any modification in the spelling of the vowel. But in some cases of the [iy-ɛ] alternation, the spellings of the "long vowel" involve combinations of vowel letters, such as *receive* and *exceed*. In those cases one needs to drop a vowel letter to produce a pronounceable "short" variant, as in *receptive* and *excessive*. (Witness, however, *please-pleasure*.) A count of how these phonemes may be spelled also shows this. Hanna and Hanna (1966) tabulate phonemes with different pronunciations in various positions. Among the 1775 words having [ey] sound in primary- or secondary-stressed positions, 1350 (76%) of them are spelled with "A" or "A-E" (where "-" is a consonant). Among the 1100 words having [ay] sounds in the same situations, 830 (75%) of them are spelled with "I" or "I-E". Among the 1310 words having [ow] in those positions, 1041 (79%) of them are spelled "O" or "O-E". As we can see, all these vowel sounds are represented at least 75% of the time by the appropriate single vowel letters. But the case of [iy] is quite different. Among the 1077 words having [iy] sounds in primary- or secondary-stressed positions, only 409 (38%) of them are spelled with "E" or "E-E". Even if we include "EA" and "EA-E" spellings into the count (272 of them) which are potentially pronounceable as "short" [ɛ] without any modifications, the percentage is still only 63%.[11]

Thus it seems quite plausible to attribute the weak performance of the [iy-ɛ] alternation in the test phase to orthographic influences. The deterioration of success rate in [iy-ε] from the learning phase to the test phase is probably because, after the learning phase, the subjects tried to hang on to the spellings of the words (even with the nonsense words) when making decisions. Such strategy gave rise to some difficulties in [iy-ε] pairs, since the alternation was more difficult to manipulate in terms of orthography. This assumption is supported by the fact that the success rate for the pair *obscene-obscenity* in the test phase was 100%, whereas for the other real pair, *receive-reception*, it was only 76%, and for the two nonsense pairs they were 76% and 60%, respectively. The difference is best explained by the fact that the [iy] and [ε] in *obscene-obscenity* are spelt consistently, while those in *receive-receptive* are not.

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[11] The "short vowels" are all spelled with single vowel letters (not including "V-E") about 90% of the time.

Of the test items, only [uw-ʌ] was clearly accepted by VS subjects. It was mentioned earlier that both Jaeger's spelling rule and Halle's 1977 version of the VS rule predicted this alternation, and hence there is no way we can settle the dispute by just looking at which alternations were accepted. However, there is a clue in favor of the spelling rule. In the three test pairs of real and nonsense words with a [uw-ʌ] alternation, *youth-young* received the fewest "YES" answers. The response frequencies of *youth-young* (15 "YES" and 10 "NO") are significantly different from those (23 and 2) associated with *reduce-reduction* (Cochran's Q=8.00, p<.05). The primary reason for the lower acceptance rate of this pair is probably because the "OU" spelling in this pair is an unusual one for these pronunciations. Hanna and Hanna (1966) tabulate 964 words with (primary or secondary) stressed [(y)uw]. Among them only 27 (3%) are spelled "OU" or "OU-E". 1189 words have stressed [ʌ], but only 29 (2%) of them are spelled "OU" (none are spelled "OU-E"). On the other hand, the 27 [uw] words constitute only 7% of the 383 words with "OU" or "OU-E" spellings in stressed positions, and the 29 [ʌ] words less than 8%. Thus, *youth-young* is another case, along with *receive-receptive*, of difficult manipulation in terms of spelling.[12]

In the two clearly rejected pairs, [aw-ʌ] and [ɔy-ʌ], the spelling rule also provides reasonable explanations for the performances. [aw] is mostly spelled as "OU", "OW" or "OU-E" in stressed positions (372 out of 378 words in Hanna and Hanna, 1966). But "OU" and "OW" are hardly a recognizable spelling for [ʌ], because there are only 29 "OU" words and no "OW" words pronounced this way (see above). If [aw] is to alternate with [ʌ], therefore, some orthographic adjustments must be made. The part of "OU" that is pronounceable as [ʌ] is "U", the second vowel letter. But it seems that in the English spelling-pronunciation rule, the first vowel letter is more prominent than the second in determining the pronunciation of the vowel sound, as one may infer from the algorithm of American English spelling presented in Hanna and Hanna (1966, p.115).[13] For example, "AI" is usually pronounced as [ey], which is the typical pronunciation of the first vowel letter "A"; "EA" and "EI" are pronounced as [iy]; "OA" is pronounced as [ow]; and so on. Dropping the first vowel letter is therefore a quite arbitrary operation.

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[12] It may be suggested that, while working on the nonsense pair *dez*[uw]*de-dez*[ʌ]*dity*, the subjects visualized the "U" spelling in the words, whereas they could not do the same for *youth-young*. This possibility is supported by another experiment of Jaeger's (1980). She read 26 nonsense words containing the six tense vowels [ey, iy, ay, ow, uw, aw] to the subjects, and asked them to write down these words in the most "normal" possible writing. For the [uw] words, the subjects spelled 76% of the time with "U" and 24% of the time with "OO".

For the [ɔy-ʌ] pair, the orthographic explanation is even more straight-forward. The regular spelling for [ɔy] is "OI" or "OY"; there is no part which can be converted to a normal spelling pronounceable as [ʌ]. The unequivocal rejection of this alternation is thus understandable from an orthographic point of view.

In the three alternation patterns, [aw-ɔ], [uw-ɔ] and [ɔy-ɔ], the subjects' performances are not clear, and hence the interpretation is more difficult. But an orthographic account also provides a reasonable explanation in this respect. As Jaeger (1980) pointed out, the [aw-ɔ] alternation is acceptable probably because "OU" or "OW" is the ordinary spelling for [aw], and the [ɔ] pronunciation could be inferred from the spelling of the first vowel letter, "O". The similar point can be made of [uw] and [ɔy]. Although [uw] is mostly spelled as "U", it is also quite frequently spelled as "OO" (see footnote on page 131). [ɔy] is always spelled as either "OI" or "OY", both containing "O". In associating the tense vowel with the lax vowel, one needs only to drop the second vowel letter in these cases. Since the alternations involve orthographic variation of some kind, they are not as readily accepted as [uw-ʌ], but because dropping the second vowel letter is much easier than dropping the first, they are more acceptable than [aw-ʌ].

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[13] "IE" and "IE-E", which are often pronounced as [iy], are an exception. But words with these spellings rarely have related words pronounced as [ɛ]. I know of only *thief-theft* and *brief-brevity*. This may be a hint that "IE" is converted to "E" ([ɛ]) only with difficulty, since one needs to drop the first vowel, just as in the case of converting "OU" to "U" ([ʌ]).

Although we have attempted to explain the behaviors of [aw-ɔ], [uw-ɔ] and [ɔy-ɔ], it should be understood that the explanation is only tentative. We do not have enough evidence to affirm that orthography is necessarily the source of these behaviors. Our only contention is that the orthographic explanation is consistent with our other claims, and seems quite reasonable. Whether this is true remains to be more forcefully demonstrated.

Chapter 4

General Discussion And Conclusion

In this chapter, we will summarize the results of our experiments and attempt to interpret them. A proposal will be made which recognizes the vowel alternation phenomenon as one involving categorical relations and adopts the "phonetic patterning" model described in Sapir (1925). It is our belief that such a model provides a realistic characterization of the vowel alternations in question.

4.1 Orthography or Phonology?

The first question we want to resolve is whether the vowel alternations are orthographic or phonological in character. In other words, do the speakers realize the relationships among the vowel alternation through their recognition that the vowels are spelled the same way, or do these vowels bear some close phonological relationship that are established independently of the spelling (i.e., during the ordinary preliterate course of language acquisition in childhood). In a way, the question is difficult to answer, because orthography is a written representation of language, and the written forms generally reflect the sound system of the language to a considerable extent, especially for languages like English which employ an alphabet. However, with all the evidence we now have at hand, we find we must agree with Moskowitz, Armbruster, and Jaeger in saying that the phenomenon has its roots in orthography.

One new argument for this conclusion has been advanced in our concept formation test. After the subjects were trained to respond to the four VS patterns, they responded positively to only [uw-ʌ] among the six test patterns. As we have pointed out, both Halle's 1977 version of the VS rule and the spelling rule (as illustrated by Jaeger, 1980) predict this result. But the fact that *only* this pattern was accepted is evidence in favor of the spelling rule, as the advocates for Halle's phonological account cannot explain why [aw-ʌ] was rejected. The orthographic explanation which we have been trying to formulate can be contrasted with the phonological explanation represented by the VS rule. As we have noted, all of the theories about the vowel shift rule as a synchronic linguistic phenomenon have included [aw-ʌ], but the results of every previous experiment which involved this disconfirmed in one form or another the validity of this pair. The results of the three experiments we conducted are consistent with the previous experiments in this respect, and thus provide further evidence for the inadequacy of a phonological explanation.

The [ɔy-ʌ] pattern which is predicted by Halle and Mohanan (1985) was also rejected in our concept formation experiment. Even the three alternations involving [ɔ]'s which are predicted by none of the theories were better received by the subjects than [aw-ʌ] and [ɔy-ʌ].[1] Thus we can confidently say that no published version of the vowel shift rule can provide a plausible explanation for the results of our concept formation experiment.

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[1] Worse still, the advocates of the VS account have to

However, the above interpretation is not without problems of its own. We have to consider the possibility of unintentionally guiding the subjects into applying the orthography strategy. The partially conflicting evidence from the production test makes us aware of this possibility. As we have seen, the response patterns of the NOM task group is quite indicative of the vowel alternation operations we have been dealing with. But there the [uw-ʌ] pattern did not come out; rather, [uw] was associated with [ɔ], which is in agreement with the SPE version of the VS rule (as in *lose-lost*). There are several possibilities for recognizing [uw-ɔ] as part of the phenomenon. The most evident explanation is that [ɔ] is the most preferred vowel before *-ity*, and the [uw-ʌ] alternation is just not strong enough to break this preference for the object vowel [ɔ]. But this explanation is not entirely satisfactory. While there are not very many real words with the [ʌ] vowel preceding *-ity* (the number in my count is 13, see Appendix IV), there is no word observed which has [ay] before *-ity*. Yet in our

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'(cont'd) demonstrate, ultimately, that the [ʌ]'s in *reduction*, *pronunciation*, and *destruction* (varying with [uw], [aw], [ɔy] respectively) are different underlyingly, because according to Halle and Mohanan (1985), these vowels are posited as /ʌ̄/, /ɨ/ and /ū/ (or /ū/; see p. 8), respectively. This is a nontrivial question if one considers positing an underlying representation for such invariant forms as *cut*: should *cut* be analyzed like *reduction*, *pronunciation*, or *destruction*, and why?

production test, [ay] surfaces as the second highest vowel in the [ɪ] source vowel category, and this cell is the only significant one in the [ay] object vowel category. This is evidence for an association between [ay] and [ɪ] that is strong enough to override conditions on morpheme structure well-formedness (e.g., [ay] is not permitted before the suffix *-ity*) as well as the object-oriented strategy, which generally tends to avoid the use of [ay] as a response vowel. The question now is, because [uw-ʌ] is in some sense true, as demonstrated in the concept formation experiment, why didn't it do the same and show some significant frequency? Obviously we have to look for other explanations.

An alternative explanation is that [ʌ] is *not* phonologically linked with [uw]. Recall that in our preference test, the subjects operated mainly on phonological grounds. While the NVS and VS patterns are both significant in different degrees for the [iy, ey, ay, ow] source vowel categories, the only back vowel significantly associated with [uw] is [ʊ]. Because [ʊ] has not been known to alternate with the other vowels, and the only reason for [ʊ] to be associated with [uw] is phonetic similarity, it is reasonable to assume that the subjects performed on the basis of the "sound" relationship, rather than the orthographic relationship. Based on this reasoning, we can say that the NVS patterns [iy-ɪ], [ey-ɛ], [ay-æ], [ow-ɔ], and VS patterns [iy-ɛ], [ey-æ], [ay-ɪ], [ow-ɔ] are *phonological* patterns. Although, as we have shown above, the VS relationships have their roots in orthography, their relationships are represented by directly linking the members of the pairs in phonological patterns, without the intervention of orthography. But for some reason the phonological link between [uw] and [ʌ] is not so well established. A full investigation into the reasons is beyond the scope of this thesis, but my speculation is that because [ʌ] is the only lax vowel that does not agree in backness and lip rounding, it does not fit into a phonologically operable pattern of the other vowel alternations. If this speculation holds up, then it seems that the original SPE formulation of the rule which requires the input to agree in backness and lip rounding is phonologically more adequate than the later versions of Halle (1977) and Halle and Mohanan (1985). At any rate, because a phonological link between [uw] and [ʌ] is lacking, when the subjects were performing on purely phonological grounds, the [uw-ʌ] alternation could not be manifested. This, I assume, is the reason behind the weakness of [uw-ʌ] in preference and production tests.[2]

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[2] Another possible explanation is that [uw-ʌ] as a phonological pattern only shows up before *-tion* suffix as in *reduce-reduction*. One way to test this possibility is to repeat the production test using *-tion* as the suffix (cf. section 4.4). But I doubt if this suffix will bring about more productivity for this pattern, because as discussed above, even the [ay] vowel which is not observed before *-ity* in real English examples can demonstrate strength in the production test, and in the concept formation test we did use the [ʌ] vowel before *-ity* in the nonsense pair, which the subjects accepted.

Thus the [uw-ʌ] pattern that showed up in the concept formation test is mainly orthographic. But it would be wrong to suggest that the subjects visualized the vowel letters at all times in making the responses. Judging from the strategy used by Jaeger's subjects (1980, pp.249-51), they relied on 'sound' rather than "spelling" when making decisions. In our concept formation test, we used nonsense words, which should in principle reduce the letter-visualization effect. But as has been shown, the difference between real and nonsense words was not significant. This suggests that subjects were able to operate on phonological grounds. Nevertheless, we should remember that the task specifically required the subjects to discover a particular relationship between the vowels, and that more than half of of the stimuli used were real words. These two factors combined may have induced the subject to form an orthography-based concept of vowel alternation. This does not mean that the experimental design was flawed. After all, there is no reason to bar orthography from creeping into phonological operations in real language situations. Skousen (1982) gives a plausible account of how orthography can affect the restructuring of phonological representations. What is meant here is that the [uw-ʌ] alternation is probably only relatable orthographically so that its phonological operation in concept formation is possible only after the orthographical connection is first made. Thus in the preference test and the production test, where the subjects did not think to seek reference from orthography, the [uw-ʌ] connection could not be made.

Now we return to the question that has concerned us from the very beginning: which pair is a true part of the VS vowel alternation phenomenon, [uw-ʌ] or [uw-ɔ] (cf. footnote on p. 7)? The [uw-ʌ] shift receives support in the concept formation test, but not in the production test; but the opposite is true for [uw-ɔ]. Since, as we suggested, the link between [uw] and [ʌ] is ultimately orthographic rather than phonological in character, what is the situation for [uw-ɔ]? Can this alternation be part of the phonological rule? The answer, in our account, is "No".

If we examine the frequencies for the pairs involving [ɔ] in both production test (NOM task) and concept formation test (VS task), we can observe that there are comparable responses. In the concept formation test, the three test patterns [aw-ɔ], [uw-ɔ] and [ɔy-ɔ] are neither clearly accepted ("YES" answers are different from those of positive reinforcement tokens), or rejected ("NO" answers are different from those of negative reinforcement tokens). They were the "undecided" patterns. In the production test (NOM task), the frequencies for [aw-ɔ], [uw-ɔ] and [ɔy-ɔ] were 48, 49, 45 respectively, out of a possible 108. These numbers do not look like coincidences, because in this task, no other frequencies fell within this range. Thus it seems that the relationships of these pairs are phonologically valid. However, this is still not sufficient proof to say that these pairs are natural alternations in the sense other pairs like [ay-ɪ] are. An alternative account is that, as suggested by Terry Nearey (personal communication, 1984), [ɔ] is a "default" back vowel, and [aw], [uw], [ɔy] simply do not have comparable partners in the sense that [ay] has [ɪ], etc. When subjects are asked to vary these tense vowels in the absence of orthographic clues, they simply resort to [ɔ] because of its high frequency and high degree of phonetic similarity with these long back vowels. Let us consider this possibility.

We have seen earlier that in the production test (NOM task), the four patterns [ay-ɪ], [ey-æ], [iy-ɛ] and [ow-ɔ] were manifested quite strongly, both with tense vowels as the source and with lax vowels as the source. But [aw-ɔ], [uw-ɔ] and [ɔy-ɔ] showed strength only with tense vowels as the source; when the lax [ɔ] was the source vowel, these patterns only received 1 or 2 responses. These alternations are not comparable with [ow-ɔ] overall, since they do not show the same kind of bidirectional strength. Thus it seems plausible to assume that these three patterns emerge only when the tense vowels were required to vary, in which case they alternated with the default vowel [ɔ].

Therefore we are led to claim that the vowel alternation phenomenon which is the result of a historical sound change is originally learned by the speakers through orthography. Furthermore, we have found support for the five alternating pairs, [ay-ɪ], [ey-æ], [iy-ɛ] [ow-ɔ] and [uw-ʌ]. Among these five pairs, four have gone on to establish direct phonoligical links between the them, while [uw-ʌ] has not, and its phonological association can only be manifested with orthographic support.

4.2 Features or Segments?

Generative phonologists have assumed that phonological segments are made up of feature matrices, and it is the practice of these linguists to formulate their phonological generalizations in terms of features. While it is true, as Halle (1962) has argued, that features are a useful device to capture linguistic generalizations otherwise not formally represented, no one has argued that features are the *only* operational phonological unit. As a matter of fact, Dobrovolsky (in press) has recently argued that phonological units other than features, such as segments and syllables, are operational at different levels. One cannot therefore take a featural description of any phenomenon for granted. Most linguists, with Schane (1974) as probably the only exception, have used features to account for the vowel alternation phenomenon, but no one has argued that the vowel alternation phenomenon is *necessarily* featural. Chomsky and Halle (1968, p.51), for example, took the feature approach as *a priori* correct. After finding that the rules directly relating [ay-ɪ] and so on were complicated in terms of features, they decided that the segmental rules were undesirable. However, although the feature system may be "otherwise well-motivated" (*ibid.*), before taking such a "free-ride" (Zwicky, 1970), Chomsky and Halle still need to establish that vowel shift is the same kind of phonological phenomenon as one which is best described in terms of features, such as English pluralization.[3]

As we have discussed in the previous section, the vowel alternation phenomenon we are dealing with has its roots in orthography. In other words, the phenomenon is not phonological by nature. When the phonological links have developed, it is no longer adequate to describe the phenomenon with features, because the ontogenetic relationships between the vowels are not derived phonologically. It is also not feasible to assume that the speakers *a posteriori* derive featural relationships between the members. For this argument, let us consider the [ay-ɪ] pair. In a featural account, a change from [ay] to [ɪ] involves changes in at least three features: besides changes in [±tense], which is true for all pairs, it also involves changes in [±high] and [±low]. In the other pairs, only [±high] *or* [±low] is involved besides [±tense]. If the featural approach is to find some kind of psychological support, we would expect the subjects to perform more poorly on [ay-ɪ] than on [ey-æ], [iy-ɛ] or [ow-ɔ]. But in all the experimental results, we find no such evidence. In many instances, subjects performed better n [ay-ɪ] than on any of the others. For example, in our production test (NOM task), [ay-ɪ] was clearly stronger than [iy-ɛ]; in our preference test and concept formation test, [ay-ɪ] was also the strongest. Jaeger's concept formation test also showed that the success rate for [ay-ɪ] was the highest among the four positive patterns (1980, p.245). In Steinberg and Krohn's study (1975), the [ay-ɪ] responses (20) were distinctly high among the elicited VS responses (27). Cena (1976, p.154) considered the formal complexity of [ay-ɪ] in comparison with other pairs, but concluded that the consequences were not supported by his results either. Thus it does not seem likely that any familiar featural relationships are established for these alternations, even after the fact.

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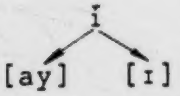
[3] Derwing and Baker (1979) provide convincing evidence that English pluralization is a featural process, and give a good example of how such an approach can be argued for.

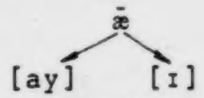
A corollary question can now be raised. Since we have indicated that the speakers have developed phonological links for the vowels in the alternations, how can these links be characterized, if not in terms of features? There are two straightforward ways this might be achieved. The first is that the two members of the pair are derived from one common underlying segment, as assumed by most theoretical accounts. The other possibility is that these two vowels are associated with each other directly, without any mediation.

Let us consider first the possibility of relating the vowels by positing a common abstract underlying form. Notice that this position does not have to presuppose a featural approach, which is merely a device designed to make the derivational relations look more natural. By rejecting the featural approach we have not necessarily rejected the "unitary representation" account. It is possible, for example, to set up a rule directly relating the surface vowels to the underlying forms without appealing to features, such as in the following diagram to relate [ay] and [ɪ]:



But this approach is not feasible. As we have indicated in the summary of previous experiments (section 2.5), there is no doubt that the speaker will prefer to choose a derived form with the *same* vowel as the source form if he is allowed to do so. Thus, if a subject is given a chance to choose any *-ity* form for *obj*[ay]*te*, he will most likely choose *obj*[ay]*tity*. If this "common abstract representation" assumption is true, then the subject needs to infer the underlying /ī/ for *obj*[ay]*te*. But then *obj*[ɪ]*tity* should be a more preferable form as its alternant, because a move from /ī/ to [ɪ] is phonetically simpler than a "return" to the vowel [ay]. Furthermore, from Armbruster's experiment IV we know that speakers prefer a lax vowel before *-ity*. We have no evidence to the effect that a phonological operation such as vowel shift takes place before *-ity*, which is required if we want to derive [ay] from /ī/ to obtain *obj*[ay]*tity*.

An alternative to positing /ī/ as the underlying form is to posit the underlying form as /ǣ/. With this assumption, the relationship becomes the following diagram:



This position was abandoned by SPE, according to McCawley (1984), chiefly because it would be difficult to account for the velar softening as in *critic* and *criticize* in terms of phonological features. But as McCawley also pointed out, velar softening is a weak and highly lexicalized phenomenon in English phonlogy, and thus cannot be effectively be used as an argument against this position. However, this position suffers from the same kind of problem as the previous assumption that the underlying vowel resembles the lax member of the pair. If one wants to make the assumption work, one would have to define the "diphthongization" environment on the one hand (for *obj*[ay]*te*) and "laxing and VS" environment on the other hand (for *obj*[ɪ}*ity*). But the "diphthongization" environment is very difficult to define. One would have to argue that *privy-privity* is an exceptionally marked case where laxing and VS take place in both forms. This is as unconvincing as arguing that *odd* and *oddity* have both undergone laxing and VS. One would ask, is there any systematic reason to mark *odd* and not *ode*? If these lexical items are all to be individually marked, one will soon find English phonology to be very uninteresting as a systematic study.

We then turn to the possibility of choosing one of the surface vowels as the common underlying form. For example, we can choose /ay/ as the underlying representation for both [ay] and [ɪ]. Facing the experimental evidence, one can claim that although the trisyllabic laxing rule is to some extent true, it is not strong enough to override the "transparency" strategy in which two related forms are to be kept as phonetically close as possible. This is a plausible assumption, but it also has one major problem with it. Since the approach is uni-directional, i.e., from [ay] to [ɪ], one would need to posit another rule to account for cases where [ɪ] is the source vowel and the subject associates it with [ay], such as in our production test (e.g., *empl*[ɪ]*t* → *empl*[ay]*tity*).[4] Thus we are using two separate rules to describe essentially the same phenomenon, a less than satisfactory result.

Hence the "unitary representation" approach is not viable, either. What we are opting for is a treatment in which the vowels are represented separately, just as they are in surface forms. For example, [ay] is represented as /ay/ and [ɪ] as /ɪ/. This approach is justified when we recognize that a change from [ay] to [ɪ] or vice versa is a categorical change, not like a change from [z] to [s] in an

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[4] Cena (1976) also did a "back formation" experiment using the same method as described in section 2.3.2, but with *-ity* forms as the source. In that case, [ɪ] was also associated with [ay]. The [ɛ-iy], [æ-ey] and [ɔ-ow] patterns were also supported.

English neutralizing environment, which can be described in terms of a general phonological process. The relationship between [ay] and [ɪ] can be represented in the following diagram:

$$\begin{tikzcd} \text{/ay/} \arrow[d] \arrow[r, phantom, "-"] & \text{/ɪ/} \arrow[d] \\ \text{[ay]} & \text{[ɪ]} \end{tikzcd}$$

In traditional terms, the above diagram means that the difference between /ay/ and /ɪ/ is phonemic, or categorical. However, there also exists a certain close relationship between the two phonemes, which is signified by "–", of a kind that does not exist between, say, /ay/ and /ɔ/, or /ay/ and /ey/. The downward arrows are phonetic actualization processes. It should be noted that the relationship between /ay/ and /ɪ/ is just that – a relationship. There is no "process" involved (cf. the via-rule in Hooper, 1976, p.48). We will characterize the relationship as a psychological association such that, for example, /ay/ is associated with /ɪ/, and under appropriate circumstances will be more readily replaced by /ɪ/ than by any other vowel. The "–" is thus an "association link". (For a more general treatment of the notion of "association" in psychology, see Anderson and Bower, 1980.)

In Armbruster's experiment I, the production test, we noted that there was a slight but significant trend in favor of increased VS responses over the six weeks. Such increase, under the interpretation of the present model, was because the nonsense pairs were recognized as related pairs over time, and the subject gradually did not depend on the surface phonetic cue as the sole means of expressing this relatedness, thus giving way to the trisyllabic laxing rule. As demonstrated by Armbruster's experiment IV and Randall's (1980) experiment, speakers generally have a good idea about what a well-formed *-ity* word should be. When this well-formedness feeling gradually gains power over time, a tense vowel is *replaced* by, not changed into, a lax vowel which is in a close relationship with the original tense vowel.

The above proposal in actually not new. It is consistent with Sapir's (1925) theory of "phonetic patterning" which McCawley (1984) proposes to revive. In Sapir's model, a sound is assigned a "place" in a phonological pattern in relation to other sounds. In this way, it is possible to treat the English /f/ as more closely related to /v/ (cf. *wife-wives*, *leaf-leaves*, etc.) than /p/ is to /b/. By the same token, we can express a close relationship between /ay/ and /ɪ/ which is of a kind that does not hold for, say, /aw/ and /ʌ/. The vowel alternation pattern is representable by the following diagram:

/ay/	/ey/	/iy/	/ow/	/uw/
|	|	|	|	|"U"
/ɪ/	/æ/	/ɛ/	/ɔ/	/ʌ/

Where the "U" beside the line between /uw/ and /ʌ/ indicates that the phonological link can be established only through the orthography. While the orthography, as the ontogenetic medium for the phonological links, is backgrounded in other pairs, "U" remains in the foreground for the phonological link between /uw/ and /ʌ/.

In the diagram, the vowels in the top row are tense while those in the bottom row are lax. The meaning of this arrangement can be illustrated by a parallel case in English stop consonants:

/p/ /t/ /k/
/b/ /d/ /g/

The difference between this diagram and the previous one is that there is no line connecting the voiceless stops with their voiced counterparts. We do of course feel that, for example, /p/ is more closely related to /b/ than it is to /t/ on purely phonetic grounds. Yet /p/ and /b/ are not morphologically interchangeable in the way that /ay/ and /ɪ/ are, though in some cases, such as after /s/, they are neutralized.[5] No such relationship exists between /p/ and /t/. Moreover, /p, t, k/ are felt to belong to one class of sounds in that they are distributionally comparable, and so are /b, d, g/. The same points can be said of the vowel alternation pairs. Recall that in the summary of previous experiments, it was found that the tense vowels seem to be more "at odds" with each other, i.e., when they are to vary, they are more likely to become lax vowels. However, the tense vowels form a distributionally comparable class (e.g., word-finally) and so do the lax vowels (e.g., before *-ity*).

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[5] John Ohala has pointed out (personal communication, 1985), that there are cases such as *describe-description* in which /b/ and /p/ are morphophonemic alternants, and are therefore potentially related. To the extent that speakers are cognizant of such alternations, we might reasonably assign an "association link" between these two phonemes, as well. But the fact that /p/ varies with /b/ in some such cases does not guarantee that native speakers are necessarily aware of the relationship, just as we cannot say *a priori* that native speakers necessarily relate [aw] and [ʌ] on the basis of mere exposure to such word pairs as *pronounce-pronunciation*. Formal, descriptive evidence is no substitute for experimental, psychological evidence.

This model can also accomodate the fact that in some cases some of the alternations are often much weaker than others. For example, in our production and concept formation tests we have found that [iy-ɛ] was the weakest. But in Armbruster's experiment I the [iy-ɛ] alternation was the strongest – it accounted for 44% of the alternations. Such variability is allowed in this model by stating the differing strengths in different situations. In the SPE model, since the alternations are accounted for by one rule, there is no provision for the possibility of such differential alternation strengths.

As one can imagine, the kind of phonetic patterning described must be multi-dimensional, as each segment has different relations with different segments. This model also resembles Schane's (1974) model of "phonological space", which is also multi-dimensional. But Schane tried to justify his "phonological space" in terms of phonological features alone, i.e., he was concerned with evaluating what kind of patterns are more natural in purely phonetic terms.

In his model, the following pattern would be valued more highly than the one we have:

/ay/	/iy/	/ey/	/ow/	/uw/
|	|	|	|	|
/æ/	/ɪ/	/ɛ/	/ɔ/	/ʊ/

But it seems to me that there is not much reason for a psychological-based phonological pattern (or "phonological space") to be evaluated by phonetic features, especially when the pattern is not phonetic in origin. Sapir (1925) has said it well:

> ...it is most important to emphasize the fact, strange but indubitable, that a pattern alignment does not need to correspond exactly to the more obvious phonetic one. It is most certainly true that, however likely it is that at least analysis patternings of sounds are based on natural classifications, the pattern feeling, once established, may come to have a linguistic reality over and above, though perhaps never entirely at variance with, such classification. (p.27)

There are many ways besides phonology by which such a "pattern feeling" can be established, and orthography is one obvious candidate. English orthography is derived from the sound system of the language, and therefore we can expect that any phonological pattern of vowel alternations derived in turn from orthography will "never [be] entirely at variance with" the phonological classifications. But in this situation any correspondence between the pattern and the phonological classifications is *a posteriori*. The pairing relations are established through phonological restructuring brought about by orthography (cf. Skousen, 1982). There is no reason why the phonological patterning should be evaluated by features on *a priori* grounds. The assignment of the link between [ay] and [ɪ] is psychological, not just phonetic, and should be measured with psychological variables. What we need to decide is whether (and how) the phonological variables can appropriately be associated with the psychological variables. We cannot merely assume that the relationship between these variables is isomorphic (cf. Linell, 1979, p.24).[6]

As we have argued above, the vowel shift relationship cannot be characterized in a "derivational" fashion on a par with generative treatments of the English plural /z/. Rather, we feel the "phonological patterning" is more appropriately described in terms of "relational" or "organizational" rules. These rules operate on the basis of phonological associations, and demonstrate productivity through readjusting the relationships of various phonological forms. Thus, *obj*[ay]*tity* is replaced by *obj*[ɪ]tity when the speaker feels a misfit of a tense vowel in the latter environment. The associative link between

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[6] Schane (1984) discarded the use of the standard distinctive features in describing the vowel shift patterns. He maintained that "the standard distinctive features do not always characterize properly the underlying mechanisms of certain vowel changes. These inadequacies...stem from a too close association with phonetic substance." Thus he proposed the use of such more abstract features as "tonality" and "aperture" to characterize the vowel shift phenomenon. How adequate these features are in representing this basically psychological phenomenon of vowel alternation is a separate question; nevertheless, this seems to me to be a plausible move.

[ay] and [ɪ] allows for such a replacement. Rules of this kind are thus very low on the applicational hierarchy, as they do not define surface phonetic constraints and are often sacrificed in favor of semantic and/or morphological transparency.

Therefore, summarizing the discussions in this section, we advocate a *segmental* treatment of the vowel alternation phenomenon. The relationships between the vowels are expressed within a model of phonological patterning in which each (taxonomic) vowel phoneme is recognized as a separate category (cf. the definition of "phoneme" in Skousen, 1981, p.55). The phonological representation for a morpheme is only as abstract as the taxonomic phonemic level. Any generalizations beyond this level ought to be expressed by the relational phonological patterns sketched above. This proposal recognizes the psychological nature of the phenomenon and treats the problem as such.

4.3 On Linguistic Rules

Language as rule-governed behavior has been the central notion of the transformational-generative theory of linguistics. Rules as conceived by TG grammarians are what largely characterizes linguistic competence. The use of the notion of "rule" can be traced back to the very beginning of the study of grammar. But the TG notion of rule is quite different from the one traditionally conceived. While the traditional notion of rule is "concrete" and can be directly "elicited from surface structures" (Schlesinger, 1967, p.399), the TG notion of rule is "abstract" and applies to "representations that are quite remote from the physical signal" (Chomsky, 1968, p.53). As Derwing (1973, p.39) pointed out, the TG grammarians seek a "description of the highest possible generality." It is this role that the TG grammarians assign to rules. In order to do this, TG grammarians allow their rules, for example, to apply to the output of other rules. In this way the surface irregularities can usually be accounted for by sequential applications of rules on the underlying and intermediate representations. A rule, then, can be infinitely remote from the surface generalizations; the rules, and the underlying representations they apply to, are necessarily abstract.

Since the TG grammarians recognize "rule" as the single underlying mechanism that governs all of linguistic behavior, they have rejected other notions such as "analogy". Kiparsky (1975, p.189) specifically argued that "at the point at which the analogies begin to make the right generalizations, they are indistinguishable from rules." In other words, according to Kiparsky, analogies are not "right generalizations"; only rules are. As Kiparsky regards rules as having the qualities of being context-sensitive, operating in terms of distinctive features, and applying sequentially and cyclically (Kiparsky, *ibid.*), it is obvious that his notion of "rule" is quite typical of the TG grammarians', and is not compatible with the notion of "analogy". Analogy as a functional mechanism in linguistic behavior is usually understood as deriving new forms on the basis of comparing (analogizing) them to old forms that are seen as parallel to them in some way. For example, if a subject produced [vərænəti], when given [vəreyn] and asked to add *-ity* to the end of the word, it could be argued that the subject did this because he "analogized" on the basis of a pattern such as *sane:sanity=verane:X*. Kiparsky (1974) argues against such an operation because it allows for such undesirable forms as **heye*, meaning "to see", to be derived from the analogy *ear:hear=eye:X*. Such an argument is *formally* plausible; but Kiparsky fails to take into account an important psychological factor on the part of the language learner: language learning is a series of hypothesis testing processes. No language learner will generate a new form and stick with it on the basis of just *one* comparison. It is possible that the language learner might form an initial hypothesis on the basis of a single comparison (witness the classical *nosigate* and *two-mation* examples of Sturtevant, 1947), but if the hypothesis is not supported by other examples, then the language learner is likely to abandon it.

However, if the preliminary hypothesis of the language learner is supported by some other examples he observes, then this forms an "analogical chain" (Householder, 1971, pp.61-80) from which the language learner can abstract more generalized notions. The speaker can abstract the notion of "voicing" by the analogical chain *bet:pet=bad:pad=big:pig=...=zoo:sue=zink:sink* and so on. He can also abstract a rudimentary notion of "vowel shift alternation" by first analogizing *sane:sanity=verane:X* (i.e., [eyn-æn]). Later on he will encounter other forms to establish an analogical chain such as *sane:sanity=opaque:opacity=grave:gravity=verane:X*, such that the more general relationship [ey-æ] is realized. We have to notice that this kind of abstraction and generalization is deeply rooted in concrete forms, and is directly retraceable from the surface. This analogy-based "rule" is quite different from the notion used by TG grammarians under the same name (cf. Derwing, 1973). In our interpretation of the term, a rule cannot easily rid itself of the information which characterizes its prototypical members. Thus even after the generalized [ey-æ] rule is learned, a form like *verane* is more likely to be changed to [vərænəti] (on the basis of such extant prototypes as *sanity* and *profanity*) than *verafe* is to become [vəræfəti] (since there are no well-formed prototypes in *-afity*), and naturalness judgements would also be expected to reflect this same kind of preference (as in the Armbruster study).

Therefore the notions of rule and analogy are not mutually exclusive; they differ only in the degree of abstraction and generality. At the more "concrete" end, analogy recognizes a bigger chunk of the stimulus and operates on that basis. Thus in our preference test, the subjects recognize not only the [ow] in [dɪskowl], but the following consonant [l] as well. When [owl] is recognized as a whole, the [ow-ɔ] rule is overridden by the strong tendency to analogize the object form with the highly frequent *-ality* words. In Myerson's production test, we also found that the subjects in some cases added *-ality*, *-idity* and so on, instead of adding the required *-ity* to the nonsense root (1976a, p.147). Ohala (1974) also suggested that an analogical strategy was behind his subjects' performance.

There is no doubt that language learners will abstract various kinds of generalizations from the linguistic data to which they are exposed. But the TG grammarians have assumed that the language learner will extend the abstraction beyond surface generalizations. As Derwing (1973, p.310) argued, the rules conceived in this way are "incapable of a direct behavioral interpretation" and "inherently unlearnable" in terms of any known principles of learning. In many ways, these rules look like "norms for the grammarian's behavior when he is practising linguistics (generative) analysis" rather than "norms of primary linguistic data" (Linell, 1979, p.23fn). The result of this abstract analysis is, as mentioned above, the postulation of an abstract segment /ī/ as the underlying representation for [ay] and [ɪ]. But the evidence of the vowel alternations we have at hand suggests that the subjects are aware of the difference, say, between

[ay] and [ɪ]. Therefore at least at some level any theory which claims to have psychological reality must register this fact. That is, both the "abstract" theory like SPE and the "concrete" theory like ours require the same memory space in terms of surface phonological units. The theory that requires more abstracting power of the language learner and makes more assumptions about human cognitive capacities will have to bear the burden of proof.

Another comment to be made about the vowel alternation as a TG "rule" is whether it is generally realized by the speakers at large. Since in the TG notion, language is characterized as rule-governed behavior, then when a rule is proposed, it implies that every competent mature speaker of the language ought to have possession of that rule. But the experimental evidence shows substantial individual differences in the realization of the vowel alternation phenomenon. In our concept formation test (VS task), 10 out of 35 subjects did not reach criterion, while two among those who reached criterion did it from the very first item. In our production test (NOM task), of the 24 possible SPE VS response patterns (tense-lax and lax-tense, in two replications), three of the 54 subjects made only two VS responses, and one made no VS response at all; on the other hand, two of the subjects made 15 VS responses, and another subject made 17 (out of a possible 24). Similar observations can be made from the results of other experiments (cf. section 2.1.1.4). Such inequality in the degrees of awareness (both between and within individual speakers, as noted earlier) indicates that generalizations of this kind do not play an important role in defining the notion "native speaker of a language." In other words, we claim that the mastery of these vowel alternation relationships is not a crucial part of the knowledge or ability of an ordinary competent language user. As we have suggested, the phenomenon is mainly psychological and is quite low on the scale of productivity; this kind of variable or non-deterministic behavior is therefore to be expected.[7]

In conclusion, we have argued that the vowel alternation rules are individually realized, though some may well be related by virtue of the fact that they all have roots in orthography. The vowel alternation relations can be expressed by the "analogical" rules which form the basis of phonological associations between the members of the vowel pairs. The ability to associate the vowel variants need not be possessed by every competent native speaker of English, and thus is not part of the core knowledge of the language.

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[7] Cf. the via-rules discussed in Hooper (1976, p.17); and the morphophonemic level and sliding scale of productivity discussed in Dobrovolsky (In press).

4.4 Limitations of the Study and Suggestions for Future Investigations

This thesis dealt mainly with the source-oriented phenomenon of vowel alternations. It was assumed in designing the experiments that the object forms would not have any significant effects on the vowel alternation activities. However, as has been demonstrated in our production test, the responses were strongly object-oriented. Even with the NOM task where the VS activities were observable, the object-oriented strategy was still dominant. Since our production test did not control for the post-vocalic consonant, we cannot be sure whether the consonants had affected the behavior of the vowel changes. One way to test this effect is to repeat the production test with the following modification: since there were 13 vowels and 14 post-vocalic consonants, there are 182 VC combinations. If a subject is tested for 26 items, then it will take 7 subjects to finish all combinations. With 70 subjects, we should have a fairly good sample for each pattern. In this way we can look into the possible effects the consonants may have on the vowel change activities.

On the orthography side, our study served to confirm the influence that orthography can have on the vowel alternations. Based on the results of our three experiments, we suggested that [ɔ] was the default vowel in back vowel alternations, and that the [uw-ʌ] association can only be established through orthography. This was primarily based on the fact that [uw-ʌ] was accepted by subjects in concept formation experiment, but did not show strength in preference and production experiments. Since we used *-ity* forms in both preference and production (NOM task) experiments, one may raise the objection that [ʌ] before *-ity* is probably stereotyped. Witness that for those *-ity* forms containing [ʌ], 11 out of 13 are *-undity*'s (see Appendix IV), and none of these are derived from adjectives containing [uw] as the stem-final vowel. Therefore objections could be raised concerning the orthographic status of [uw-ʌ] link. One can argue that while the phonological link for this pair is only possible through orthography before *-ity*, it is possible that a direct phonological link has been established in forms such as *reduce-reduction*, or *consume-comsumption*. One way to test this is to repeat our preference and production tests, using *-tion* as the suffix. If the [uw-ʌ] alternation shows up in that test, then our claim will have to be modified.

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Appendix I

Instructions and Procedures for Preference Test

In English we can add a suffix *-ity* to the end of an adjective to make a noun. For example, adding *-ity* to *obese* we get *obesity*. In some cases, besides adding *-ity*, we have to change the vowel as well. For example, adding *-ity* to *divine*, we get *divinity*, and the vowel sound is also changed. In this experiment we are interested in finding out what the more natural changes of vowels are. We would like you to help us decide which forms sound best to you. You will hear on the tape some artificially constructed adjective forms. For each adjective, you will hear two corresponding *-ity* forms. Please indicate which *-ity* form you think will go with the adjective form. For example, you will hear,

ɛmbayv   *ɛmbayv*, *ɛmbɛvətɪ*   or   *ɛmbayv*, *ɛmbɔvətɪ*

If you feel the first *-ity* form sounds better, mark A on your answer sheet. If you prefer the second pair, mark B. You may not like either of them, but please choose the pair that you feel to be "better". Please do not leave any items blank.

(Order 1)

1.	səbtays	səbtays, səbtays,	səbtɔsətɪ səbtɛsətɪ	*or*
⋮			⋮	
90.	ɛmpawd	ɛmpawd, ɛmpawd,	ɛmpɪdətɪ ɛmpʌdətɪ	*or*

(Order 2)

1.	ɛmpawd	ɛmpawd, ɛmpawd,	ɛmpʌdətɪ ɛmpɪdətɪ	*or*
⋮			⋮	
90.	səbtays	səbtays, səbtays,	səbtɛsətɪ səbtɔsətɪ	*or*

Appendix II

List of Stimuli Used in Production Test

A. NOM Task

Instructions:

In English there are some adjective forms that have corresponding noun forms ending in *-ity*. Some examples are *divine-divinity, serene-serenity, profound-profundity*. In these instances, the stressed vowel changes. Can you think of some more examples? (Cues: *profane-profanity, obscene-obscenity, verbose-verbosity*.) Here we have made up some nonsense words which we will pretend to be adjectives. So we supply them with adjective meanings. I would like you to give their corresponding *-ity* forms that show vowel change.

Frame: (*prestice*) means (*good at leading people*)

The boy/Ms. Smith/The dog/etc. is *prestice*.

He/She/It is *prestice*.

He has a lot of __________.

1. prestice [prɪstays] = good at leading people
2. emprile [ɪmprayl] = angry
3. distaze [dɪsteyz] = confused
4. probame [probeym] = lucky
5. defeen [dəfiyn] = lazy or bored
6. subdeeve [səbdiyv] = nice
7. predowp [prɪdawp] = very happy
8. denowk [dənawk] = willing to help
9. exote [ɛgzowt] = contented with what one has
10. disnofe [dɪsnowf] = picking on everything
11. purvoosh [pɚvuwš] = taking things easily
12. dezude [dəzuwd] = careful
13. exhig [ɛkshɪg] = jealous
14. emplit [ɛmplɪt] = expressive

15. malbep [mælbɛp]
= vicious

16. envel [ɛnvɛl]
= loveable

17. dismaz [dɪsmæz]
= drowzy

18. envab [ɛnvæb]
= quick-tempered

19. dismook [dɪsmʊk]
= hard to please

20. subfoosȟ [səbfʊš]
= tolerant

21. preslon [prɪslɔn]
= hypocritical

22. expov [ɛkspɔv]
= readable

23. prowuff [prowʌf]
= open-minded

24. surnuss [sɚnʌs]
= brave

25. enfoig [ɛnfɔyg]
= sloppy

26. demoib [dəmɔyb]
= fast and efficient

B. PAST Task

Instructions:

We have in English irregular verbs such as *throw-threw*, *mean-meant*, *run-ran*, where the vowel changes. Can you think of some other examples? (Cues: *swim-swam*, *bite-bit*, *stick-stuck*.) Here we have some made-up words referring to special actions. We will pretend that these made-up words are all irregular verbs. I will read you some sentenses containing the made-up words, and I would like you to supply their irregular past forms.

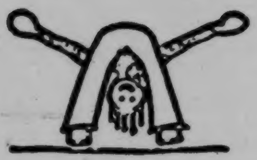
Frame: Here is a dog/man/lady/etc. who knows how to *stice*.

He/She/It *stices* everyday.

He/She/It did the same thing yesterday.

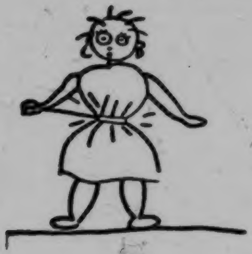
Yesterday he/she/it __________.

1.



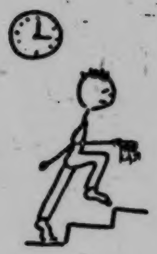
To stice [stays]

2.



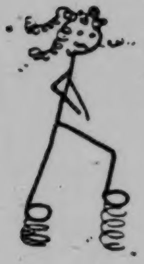
To prile [prayl]

3.



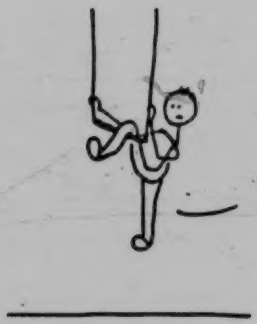
To taze [teyz]

4.



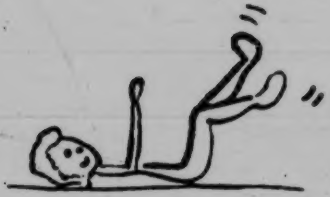
To bame [beym]

5.



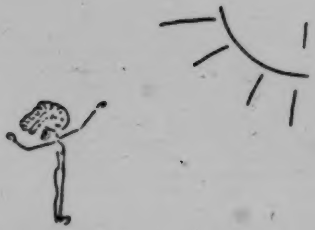
To feen [fiyn]

6.



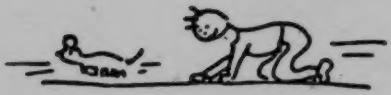
To deeve [diyv]

7.



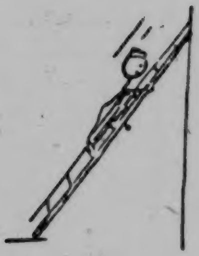
To dowp [dawp]

8.



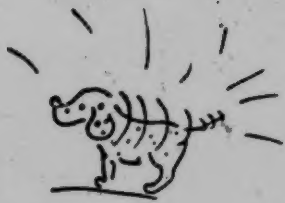
To nowk [nawk]

9.



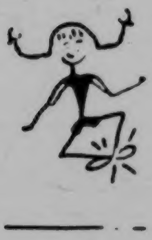
To zote [zowt]

10.



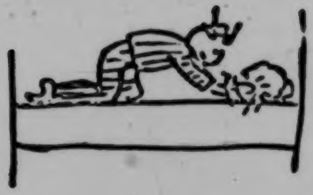
To nofe [nowf]

11.



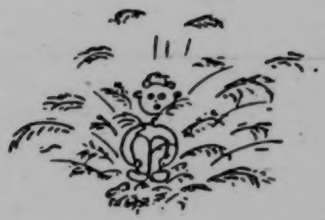
To voosh [vuwš]

12.



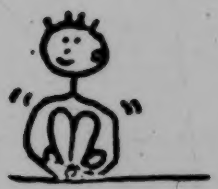
To zude [zuwd]

13.



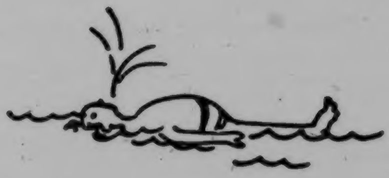
To hig [hɪg]

14.



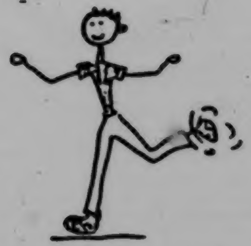
To plit [plɪt]

15.



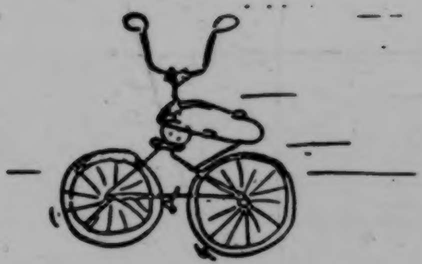
To bep [bɛp]

16.



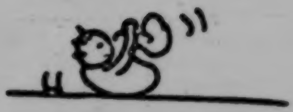
To vell [vɛl]

17.



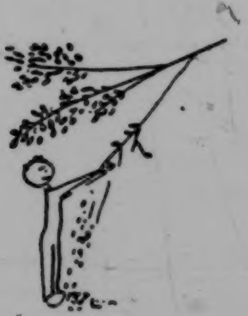
To maz [mæz]

18.



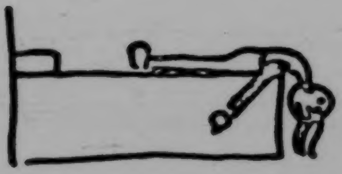
To vab [væb]

19.



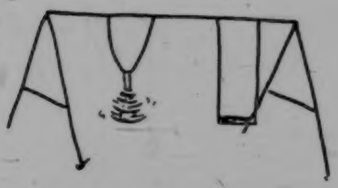
To pook [pʊk]

20.



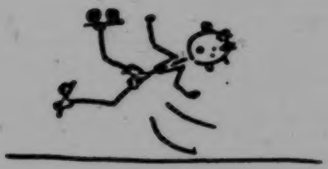
To doosh [dʊš]

21.



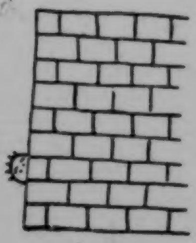
To slon [slɔn]

22.



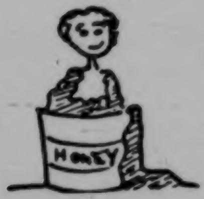
To pov [pɔv]

23.



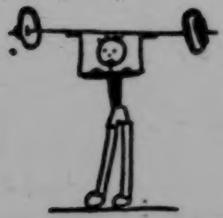
To wuff [wʌf]

24.



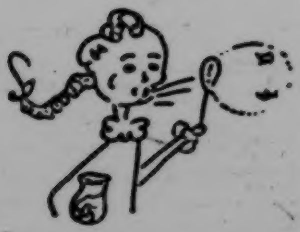
To nuss [nʌs]

25.



To foig [fɔyg]

26.



To moib [mɔyb]

C. PLUR Task

Instructions:

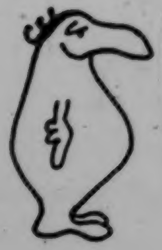
In English there are some nouns that have irregular plural forms, such as *man-men*, *foot-feet*, *child-children*, where the vowel changes. Can you think of some other examples? (Cues: *mouse-mice*, *goose-geese*, *woman-women*.) Here we have some made-up words that are names of some strange creatures. We will pretend that these names all have irregular plural forms. I will read you some sentences containing these made-up words, and I would like you to supply their irregular plural forms.

Frame: This is a *stice*.

Here is another *stice*.

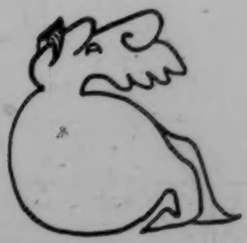
There are two _____ in the picture.

1.



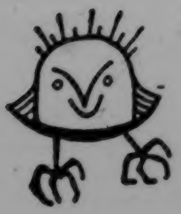
A stice [stays]

2.



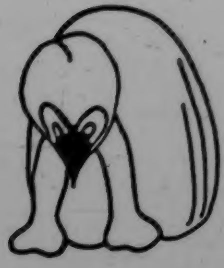
A prile [prayl]

3.



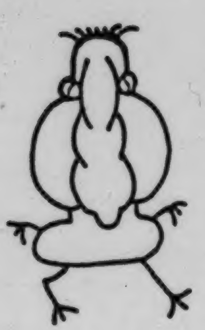
A taze [teyz]

4.



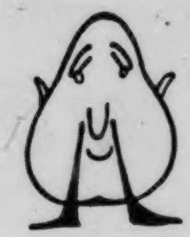
A bame [beym]

5.



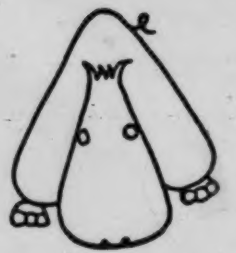
A feen [fiyn]

6.



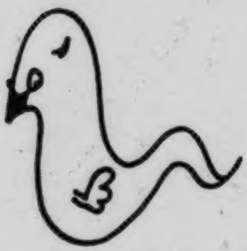
A deeve [diyv]

7.



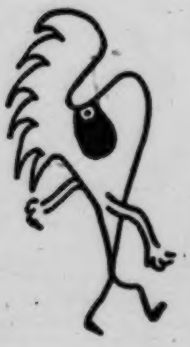
A dowp [dawp]

8.



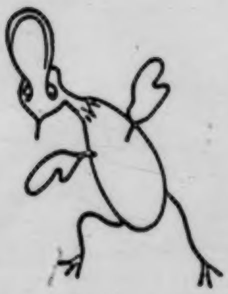
A nowk [nawk]

9.



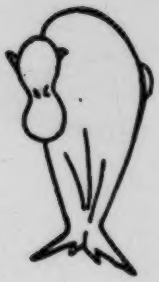
A zote [zowt]

10.



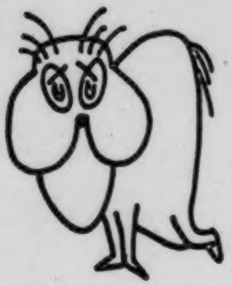
A nofe [nowf]

11.



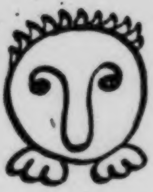
A voosh [vuwš]

12.



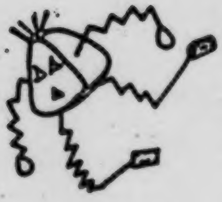
A zude [zuwd]

13.



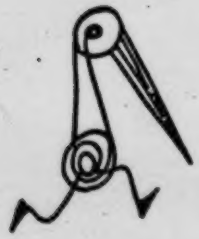
A hig [hɪg]

14.



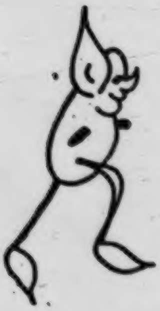
A plit [plɪt]

15.



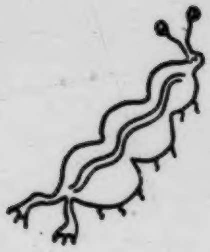
A bep [bɛp]

16.



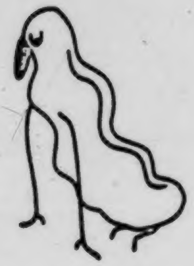
A vell [vɛl]

17.



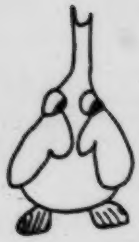
A maz [mæz]

18.



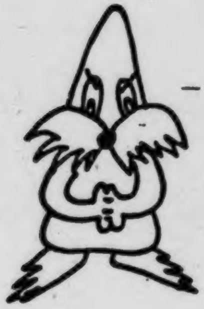
A vab [væb]

19.



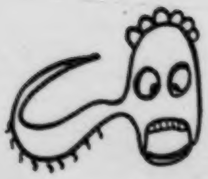
A pook [pʊk]

20.



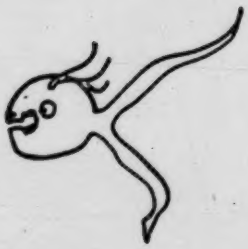
A doosh [dʊš]

21.



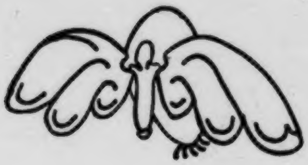
A slon [slɔn]

22.



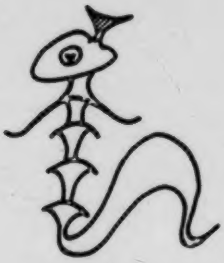
A pov [pɔv]

23.



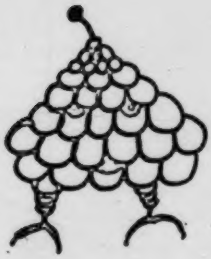
A wuff [wʌf]

24.



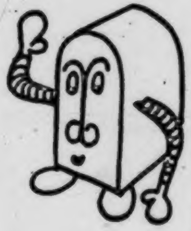
A nuss [nʌs]

25.



A foig [fɔyg]

26.



A moib [mɔyb]

Appendix III

Data from Production Test

Group 1 (UNIV) and 2 (HS) are indicated by the first digit of subject ID. Items are ordered according to the list in Appendix II. Codes are: y=[ay] e=[ey] i=[iy] w=[aw] o=[ow] u=[uw] ɪ=[ɪ] ɛ=[ɛ] æ=[æ] ʊ=[ʊ] ɔ=[ɔ] ʌ=[ʌ] œ=[ɔy] 0=no response

A. NOM GROUP

102	i	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɔ	ɔ	ɔ	ɔ	ɔ	e	i	ɪ	v	e	ɛ	ɔ	o	ɪ	o	ʊ	ɔ	ɔ	ɪ
105	ɪ	ɪ	ɔ	æ	ɪ	ɪ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɪ	æ	ɔ	ɪ	ɔ	ɔ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ
108	ɪ	ɪ	æ	æ	y	ɪ	ɔ	ɔ	ɔ	ɔ	o	ɔ	y	æ	i	æ	e	ɔ	u	u	o	o	ʊ	æ	u	u
111	ɪ	ɪ	ɪ	æ	ɪ	ɪ	æ	æ	ɔ	æ	æ	ɪ	y	y	e	y	ɪ	ɪ	y	y	ɛ	y	ɪ	æ	æ	ɛ
113	i	ɪ	æ	æ	æ	ɪ	u	u	i	u	e	i	i	e	i	e	e	e	u	u	o	o	u	u	e	i
116	ɪ	æ	æ	æ	æ	ɛ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	æ	ɔ	ɪ	e	e	ɔ	ɔ	æ	o	ɪ	ɔ	ɔ	ɔ
119	ɔ	ɪ	ɔ	æ	y	ɪ	ɔ	u	ɔ	ɔ	ɔ	e	y	y	ɔ	ɪ	ɔ	e	ɔ	y	o	o	ʊ	ɔ	v	ɔ
122	e	æ	æ	æ	ɛ	e	ɔ	u	ɛ	ɔ	e	e	e	æ	y	o	e	e	e	ɛ	æ	ɪ	ʊ	y	u	ɔ
125	ɔ	ɪ	æ	æ	æ	ɛ	ɔ	ɔ	æ	ɔ	ɔ	o	æ	æ	ɪ	o	ɔ	ɪ	æ	æ	æ	o	ɪ	æ	æ	ɔ
128	ɔ	ɪ	æ	æ	ɪ	ɛ	ɔ	ɔ	ɔ	ɔ	ɔ	e	ɛ	ɔ	ɔ	ɔ	ɔ	ɛ	ɔ	ɔ	ɛ	ɛ	ɔ	ɔ	ɔ	ɔ
131	ɪ	ɪ	æ	æ	ɛ	ɛ	o	o	ɔ	ɔ	0	æ	ɛ	y	y	i	e	i	o	u	e	o	ʊ	u	0	w
136	ɪ	ɪ	æ	æ	y	ɪ	ɔ	ɔ	ɔ	ɔ	æ	ɔ	ɛ	y	æ	ɔ	e	e	ɪ	œ	ɛ	œ	ɔ	æ	ɔ	ɔ
139	æ	ɛ	æ	æ	ɛ	ɛ	ɪ	ɪ	ɛ	ɪ	æ	ɛ	æ	ɛ	ɪ	æ	ɛ	ɪ	ɔ	æ	ɪ	ɪ	ɪ	ɛ	æ	ɪ
142	ɪ	ɛ	æ	ɛ	ɛ	ɛ	ɔ	ɔ	ɔ	ɛ	ɔ	ɔ	ɛ	ɔ	ɪ	ɔ	ɛ	ɛ	ɔ	ɪ	ɛ	ɛ	ɪ	ɔ	ɔ	ɛ
145	ɔ	ɔ	æ	æ	ɪ	æ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	u	ɪ	u	ɔ	e	ɔ	ɔ	æ	o	u	ɔ	ɔ	0
148	æ	e	æ	æ	ɪ	ɛ	ɪ	ɔ	ɔ	ɔ	ɔ	ɔ	y	y	ɪ	e	ɪ	y	æ	u	æ	u	ɪ	æ	ɪ	ɪ
151	ɔ	e	w	æ	æ	ɪ	e	e	ɔ	v	o	o	æ	ɔ	æ	o	ɔ	o	v	o	æ	o	o	ɪ	ɔ	ɔ
154	æ	ɪ	æ	æ	ɛ	ɛ	ɪ	ɔ	ɔ	ɔ	æ	ɔ	æ	æ	ɪ	ɔ	ɔ	e	ɪ	ɪ	ɪ	ɛ	ɔ	æ	ɔ	ɪ
157	ɪ	ɪ	ɛ	æ	ɪ	ɛ	ɛ	ɔ	ɔ	ɔ	v	ɔ	æ	y	ɪ	ɪ	i	e	ɪ	v	ɪ	o	ʊ	ɪ	ɔ	ɪ
160	ɔ	o	æ	æ	æ	ɛ	æ	ɔ	ɔ	æ	ɔ	ɔ	æ	ɔ	ɔ	o	ɔ	ɔ	æ	æ	ɪ	æ	æ	æ	ɔ	æ
163	ɪ	ɪ	u	æ	ɛ	y	u	ɪ	ɔ	æ	ɔ	ɔ	y	ɔ	u	ɪ	ɪ	ɪ	ɛ	ɪ	ɪ	u	ɪ	u	ɪ	u
166	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɔ	ɪ	ɪ	ɪ	æ	ɛ	ɪ	ɪ	ɪ	ɪ	ɛ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ
169	ɪ	ɪ	æ	æ	ɛ	ɪ	ɪ	ɪ	ɪ	ɔ	ɔ	ɪ	ɔ	ɔ	ɪ	ɔ	ɪ	ɪ	ɔ	ɔ	ɪ	o	ɪ	ɔ	ɔ	ɪ
172	ɪ	ɪ	æ	æ	ɪ	ɪ	v	v	ɔ	v	ɛ	ɔ	æ	æ	i	æ	ɔ	e	ɪ	ɔ	ɛ	o	ʊ	ɪ	ɔ	ɛ
175	ɪ	ɪ	æ	æ	ɛ	ɛ	u	o	ɔ	ɔ	o	o	y	e	y	ɪ	e	e	u	u	o	o	ʊ	u	ɔ	ɔ
178	ɛ	ɪ	ɔ	æ	ɛ	ɛ	ɔ	ɔ	ɔ	w	ɔ	ɔ	æ	y	ɔ	i	e	e	ɔ	ɔ	ɛ	o	ɔ	ɔ	e	ɔ
181	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	i	y	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ
184	e	ɛ	æ	æ	ɪ	ɔ	ɔ	o	u	ɔ	o	o	æ	ɔ	æ	e	w	ɔ	ɪ	æ	ɪ	æ	æ	ɪ	e	ɔ
187	ɪ	ɪ	æ	æ	y	ɛ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	i	y	i	ɔ	e	e	ɔ	ɔ	o	o	ɪ	ɪ	ɔ	i
190	ɪ	ɪ	ɪ	æ	y	ɛ	ɪ	ɪ	v	ɪ	ɪ	ɪ	y	y	ɔ	i	e	e	ɔ	ɪ	ɪ	ɪ	ɪ	ɛ	o	ɔ
203	ɛ	ɪ	ɪ	ɛ	ɛ	ɛ	ɔ	ɔ	ɛ	ɔ	ɔ	ɛ	ɛ	ɛ	æ	æ	ɛ	ɛ	ɛ	ɛ	ɛ	ɛ	ɛ	ɛ	ɛ	ɛ
206	ɛ	œ	æ	ɛ	ɛ	ɛ	0	ɛ	ɔ	u	ɔ	ɛ	ɛ	æ	ɪ	ɪ	ɛ	ɛ	ɛ	ɛ	0	ɛ	ɔ	ɪ	o	ɪ
209	w	w	w	ɪ	w	w	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	w	i	ɪ	ɪ	ɔ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ	ɪ
212	ɪ	e	ɛ	ɪ	ɔ	ɪ	ɛ	0	ɔ	ɔ	ɔ	ɔ	0	i	ɪ	ɔ	ɛ	ɔ	ɔ	ɔ	ɪ	o	ɔ	ɔ	ɔ	ɔ
215	ɪ	æ	æ	æ	æ	æ	ɔ	ɔ	ɔ	ɔ	ɔ	ɪ	æ	æ	æ	æ	ɔ	ɔ	ɛ	ɪ	ɪ	æ	æ	æ	æ	ɔ
218	ɪ	ɪ	ɔ	æ	ɪ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	æ	ɪ	ɔ	ɔ	ɔ	ɔ	ɔ	ɛ	o	ɔ	æ	ɔ	ɔ
221	ɪ	ɪ	æ	æ	ɛ	æ	ɪ	ɔ	w	æ	æ	æ	y	y	i	i	0	0	ɔ	ɔ	0	ɛ	æ	ɪ	ɔ	ɔ

224	ɔ	ɔ	æ	æ	ɛ	ɛ	ɔ	0	ɛ	ɔ	ɔ	ɛ	ɔ	ɛ	ɔ	ɔ	ɔ	ɪ	0	ɪ	0	ɪ	ɪ	ɔ	ɪ	ɔ
227	ɔ	æ	æ	æ	ɪ	ɛ	ɔ	ɔ	0	ɔ	0	ɪ	æ	0	ɪ	e	ɔ	ɪ	v	0	ɪ	o	ʊ	æ	ɔ	ɔ
230	ɔ	e	æ	æ	ɛ	y	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	y	y	ɪ	ɔ	ɔ	ɪ	ɔ	ɔ	o	o	ɔ	ɔ	ɔ	o
232	ɛ	ɪ	ɔ	æ	æ	æ	ɛ	ɔ	æ	ɔ	æ	0	æ	ɛ	æ	ɪ	ɛ	v	o	0	o	ɪ	æ	ɪ	æ	æ
234	æ	æ	æ	æ	æ	ɪ	ɛ	æ	æ	æ	æ	æ	æ	æ	æ	æ	ɛ	i	ɔ	æ	æ	æ	æ	æ	ɔ	æ
239	ɪ	e	ɛ	ɛ	ɛ	ɛ	ɛ	ɔ	ɔ	ɔ	ɔ	ɔ	æ	æ	æ	æ	ɛ	ɛ	ɔ	ɔ	ɛ	ɛ	ɪ	ɛ	æ	ɛ
242	æ	e	æ	æ	ɪ	ɪ	æ	ɔ	ɔ	ɔ	ɔ	ɔ	æ	æ	æ	æ	ɔ	e	ɔ	æ	æ	o	ɔ	æ	ɔ	ɔ
245	ɛ	i	i	i	ɔ	ɛ	ɛ	i	w	i	ɛ	ɪ	i	0	i	æ	ɛ	ɛ	ɛ	ɪ	ɛ	ɪ	æ	ɛ	ɛ	i
248	ɪ	0	æ	æ	ɪ	ɛ	u	u	ɔ	ɔ	w	ɔ	i	i	i	i	e	e	o	u	o	o	o	i	u	0
249	ɪ	œ	æ	ɪ	æ	ɪ	ɪ	ɔ	ɛ	e	e	ɪ	æ	y	æ	æ	ɛ	ɪ	æ	0	e	ɛ	ɪ	y	y	y
252	ɪ	i	æ	æ	ɛ	ɪ	i	u	u	u	ɔ	w	i	y	i	i	e	e	ɔ	u	æ	æ	u	æ	o	v
255	ɪ	ɪ	æ	æ	ɛ	ɛ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	y	ɛ	i	i	e	e	ɔ	ɔ	æ	æ	u	ɔ	ɔ	ɔ
258	ɪ	ɪ	ɪ	ɪ	ɛ	ɛ	ɪ	ɪ	æ	ɔ	o	w	æ	ɔ	ɪ	æ	ɪ	e	v	ɔ	ɛ	ɛ	ɔ	ɛ	æ	y
261	ɔ	ɪ	ɔ	æ	ɪ	ɔ	ɔ	æ	ɔ	ɔ	ɪ	ɪ	ɔ	ɔ	ɔ	æ	e	e	ɔ	ɪ	v	o	æ	ɔ	ɔ	ɔ
264	ɪ	ɪ	ɪ	æ	ɪ	ɪ	o	œ	w	w	w	w	æ	ɛ	ɪ	ɪ	ɪ	ɛ	w	w	ɪ	w	ɔ	ɪ	ɪ	w
267	ɪ	ɪ	ɪ	æ	ɪ	ɪ	ɪ	ɪ	ɔ	ɪ	ɪ	i	æ	y	ɪ	æ	ɪ	e	ɪ	ɪ	ɪ	o	ɪ	ɪ	ɪ	ɪ
270	ɪ	ɪ	æ	æ	ɛ	ɛ	æ	ɔ	ɔ	ɔ	ɔ	ɔ	y	y	i	i	e	e	ɔ	ɔ	o	e	ɔ	æ	ɔ	ɔ

B. PAST FORMATION GROUP

101	æ	æ	v	ɪ	æ	e	ɛ	ɪ	æ	v	æ	ɛ	v	æ	æ	æ	v	v	æ	æ	v	æ	æ	æ	æ	v
104	i	æ	u	i	e	e	u	æ	w	w	w	w	æ	y	æ	æ	e	u	u	w	w	æ	w	æ	w	w
107	o	ɪ	ɛ	ɛ	ɛ	o	ɪ	o	u	i	ɪ	i	ɔ	ɔ	ɪ	ɔ	i	ɛ	ɛ	o	u	u	ʊ	u	w	u
109	ɔ	ɪ	æ	ɔ	e	o	ɔ	ɔ	i	v	ɔ	i	æ	æ	ɔ	ɔ	o	ɔ	æ	ɔ	æ	æ	o	æ	æ	i
114	e	0	y	ɔ	e	y	u	v	w	æ	0	ɛ	v	e	i	0	e	i	æ	ɪ	ɪ	e	æ	æ	æ	0
117	o	æ	o	æ	ɛ	æ	ɛ	o	u	æ	ɔ	ɔ	æ	æ	æ	æ	ɛ	ɔ	ɔ	ɔ	æ	ɛ	æ	æ	u	u
120	ɔ	ɛ	ɔ	æ	æ	o	æ	ɔ	ɔ	v	w	ɛ	ɔ	æ	ɔ	ɔ	ɔ	ɔ	ɛ	ɔ	v	æ	o	u	ɛ	v
123	ɪ	ɪ	ɔ	v	ɛ	o	ɪ	u	ɔ	ɔ	ɔ	ɔ	ɔ	æ	æ	æ	ɔ	ɪ	ɪ	ɔ	v	ɪ	ɔ	ɔ	ɔ	ɪ
126	u	i	i	i	ɛ	e	ɛ	ʊ	i	i	æ	i	æ	æ	i	e	e	ɔ	ɪ	ɛ	ɪ	e	i	æ	e	i
129	e	œ	o	ɔ	e	o	y	y	æ	i	æ	y	ɔ	æ	æ	ɔ	ɛ	ɔ	æ	æ	ɛ	ɛ	æ	ɛ	i	i
132	w	w	w	i	w	w	ɪ	i	i	w	i	i	v	w	w	i	i	i	ɪ	i	i	i	i	w	ɪ	i
134	æ	u	æ	i	e	æ	v	v	e	æ	e	v	æ	æ	æ	æ	ɛ	v	ɛ	v	æ	v	æ	ɛ	e	æ
137	v	o	v	v	ɔ	o	ɔ	ɔ	ɔ	ɔ	w	v	ɔ	v	ɔ	ɔ	v	v	ɔ	v	v	v	ɔ	ɔ	ɔ	v
140	e	ɔ	ɪ	æ	æ	y	o	œ	æ	v	æ	ɪ	æ	æ	ɔ	æ	o	o	v	æ	æ	e	æ	ɛ	æ	æ
143	v	ɪ	ɔ	ɔ	v	o	0	ɛ	ɪ	ɪ	w	o	ɔ	v	ɪ	ɪ	ɪ	ɔ	ɪ	o	ɪ	ɪ	ɪ	ɪ	0	i
146	æ	u	ɪ	i	ɔ	y	ɛ	ɛ	ɔ	v	ɪ	ɔ	æ	æ	ɪ	ɔ	u	ɛ	ɪ	æ	ɪ	ɪ	u	u	u	u
149	æ	ɪ	o	ɔ	ɛ	o	o	e	ɔ	u	æ	w	æ	æ	ɔ	e	e	ɔ	æ	w	æ	æ	o	y	y	o
152	ɔ	u	y	ɔ	ɔ	o	y	y	y	y	ɔ	ɔ	y	ɔ	ɪ	y	y	ɔ	y	y	y	y	u	y	y	y
155	ɪ	ɪ	æ	æ	ɛ	o	u	u	ɔ	u	w	v	y	y	o	i	o	e	u	o	o	o	o	u	u	o
158	ɛ	ɪ	ɛ	æ	u	ɛ	ɛ	u	u	u	ɔ	ɛ	æ	æ	æ	æ	ɛ	ɛ	ɛ	ɛ	ɛ	æ	ɛ	ɛ	u	u
161	æ	u	æ	v	æ	o	o	e	i	v	ɔ	e	e	e	ɔ	i	e	e	e	o	e	e	o	e	o	o
164	e	w	o	o	o	o	o	o	ʊ	u	o	e	æ	o	e	o	e	o	o	o	o	u	o	e	o	o
167	o	ʊ	o	o	ɛ	v	o	v	æ	v	e	ɔ	v	æ	æ	e	e	o	v	æ	v	o	o	æ	v	o
170	o	u	o	ɔ	o	o	o	o	e	v	e	e	æ	e	æ	ɔ	o	e	o	o	o	e	æ	æ	e	o
173	ɔ	ɔ	o	æ	e	o	ɔ	ɔ	ɔ	ɔ	ɔ	o	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	o	o	ɔ	u	ɔ	ɔ
176	e	e	0	æ	e	e	ɔ	e	ɔ	e	æ	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e
179	æ	æ	ɪ	æ	æ	e	æ	æ	ɔ	æ	ɔ	ɔ	æ	æ	æ	ɔ	e	ɪ	æ	æ	æ	ɪ	æ	æ	æ	ɪ
182	o	o	o	o	o	o	o	o	ɔ	v	o	o	o	o	o	ɔ	o	o	o	o	o	o	o	o	o	o
185	w	e	w	y	æ	o	e	u	u	u	e	w	o	y	o	e	o	e	ɔ	u	o	o	u	e	o	u
188	v	e	v	v	v	o	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	o	o	u	v	v
191	ɪ	e	o	ɪ	æ	o	ɪ	æ	ɪ	ɛ	æ	ɛ	æ	æ	ɪ	æ	o	ɪ	æ	æ	ɪ	ɪ	æ	u	ɪ	æ
201	ɔ	e	ɔ	0	æ	æ	æ	æ	æ	æ	æ	æ	æ	æ	æ	e	i	æ	æ	v	e	æ	æ	æ	æ	æ
204	e	e	ʊ	u	e	e	u	ʊ	e	u	i	e	æ	e	e	e	e	e	e	e	e	e	ʊ	ʊ	u	e

207	o	o	w	o	ɔ	o	e	v	u	v	w	w	ɔ	o	o	o	o	o	ɔ	e	o	u	ɔ	ɛ	o	æ
210	œ	o	œ	o	o	y	o	ɛ	ɔ	ɔ	i	o	æ	æ	ɔ	o	e	e	o	o	o	ɛ	o	o	o	o
213	o	o	o	ɛ	y	e	ɪ	y	e	y	ɪ	ɪ	e	o	y	o	e	e	y	y	o	e	o	y	e	y
216	e	i	o	o	o	o	e	o	e	i	e	o	e	e	o	o	e	o	e	o	o	o	i	e	e	i
219	æ	e	y	æ	æ	o	o	i	æ	æ	æ	æ	æ	æ	æ	u	u	ɔ	æ	æ	i	y	o	æ	æ	æ
222	æ	o	æ	æ	æ	o	æ	ʊ	u	u	æ	æ	æ	æ	æ	o	e	e	æ	æ	æ	æ	o	ɪ	ʊ	ɔ
225	ɔ	ɛ	ɔ	æ	æ	v	ɔ	ɛ	ɛ	v	ɔ	ɔ	æ	æ	w	ɔ	ɛ	ɔ	o	æ	æ	æ	ɛ	æ	ɛ	0
228	ɔ	u	ɔ	u	ɔ	o	ɔ	ɔ	u	u	ɔ	ɔ	u	ɔ	v	u	u	u	ɔ	ɔ	u	o	o	u	ɔ	u
235	ɔ	e	ɔ	ɔ	ɔ	e	v	ɛ	ɔ	e	ɔ	ɔ	ɔ	ɔ	æ	v	e	ɪ	ɔ	ɔ	æ	o	ɔ	æ	ɔ	ɔ
236	i	u	æ	i	e	o	o	u	i	u	o	v	i	i	v	i	e	e	o	u	o	o	ɪ	u	ʊ	o
237	i	æ	o	ɪ	æ	o	æ	u	i	e	ɔ	o	æ	æ	w	i	y	o	ɛ	i	ɪ	i	ɔ	æ	ɪ	u
240	ɔ	u	ɔ	ɔ	ɔ	o	v	ɔ	ɔ	ɔ	ɔ	ɔ	v	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	ɔ	æ	v	ɔ	ɔ	ɔ	ɔ
243	e	e	o	v	æ	æ	u	æ	æ	æ	v	ɔ	æ	æ	æ	w	e	e	ɔ	ɔ	e	ɛ	æ	æ	e	æ
246	o	e	o	o	o	o	o	ɛ	ɔ	æ	o	ɔ	ɔ	ɔ	æ	æ	o	o	ɔ	ɔ	v	e	æ	æ	ɔ	ɔ
250	w	œ	w	ɔ	v	v	o	ʊ	v	v	ɔ	w	v	ɔ	ɔ	ɔ	v	v	ɔ	w	v	o	o	w	ɔ	o
253	ɪ	o	æ	æ	ɛ	o	ɛ	ɔ	u	u	ɛ	v	y	ɛ	u	o	o	ɪ	ɛ	e	æ	ɛ	æ	æ	ɛ	u
256	æ	u	ɔ	ɔ	ɛ	e	æ	æ	æ	ɔ	æ	æ	æ	æ	æ	æ	ɔ	ɔ	æ	ɛ	ɛ	ɛ	æ	æ	æ	ɔ
259	i	i	i	i	æ	æ	i	i	æ	i	ɔ	o	æ	æ	i	æ	e	i	o	æ	ɛ	e	æ	æ	æ	i
262	i	e	y	y	y	y	œ	v	u	æ	æ	ɔ	æ	æ	æ	ɪ	ɪ	o	æ	æ	u	æ	æ	æ	æ	æ
265	e	ɪ	ʊ	ɔ	ɔ	e	e	v	ɔ	u	w	o	ɔ	e	u	u	v	e	v	e	e	e	e	u	v	u
268	i	i	i	i	w	y	u	i	u	v	i	o	æ	æ	i	w	e	e	æ	u	o	o	u	i	u	u
271	o	u	o	o	w	y	v	æ	æ	u	o	o	v	o	u	u	u	i	æ	œ	u	u	æ	u	u	u

C. PLURALIZATION GROUP

103	i	i	i	i	ɪ	ɪ	i	i	ɔ	i	i	ʊ	i	i	ɪ	ɪ	ɪ	i	ɛ	ɪ	o	i	i	i	ɪ	i
106	w	e	y	ɛ	ɛ	ɛ	y	æ	i	w	ɛ	i	i	y	i	e	y	e	i	ɛ	o	y	y	i	y	y
110	o	ɪ	o	ɪ	ɔ	y	y	ɔ	ɔ	y	i	o	ɔ	i	i	y	y	e	o	o	o	e	o	u	ɔ	i
112	w	i	i	i	w	o	y	y	i	i	i	i	ɔ	i	ɔ	ɔ	i	i	i	i	w	i	i	y	i	æ
115	w	w	w	w	ɛ	w	u	u	ɔ	i	w	w	e	y	i	æ	i	o	v	w	i	w	u	w	w	w
118	œ	i	u	i	u	o	u	y	i	ɪ	i	æ	ɛ	æ	o	o	œ	i	œ	y	ɛ	i	ɪ	e	ɪ	æ
121	i	ɪ	i	i	y	y	y	i	y	y	i	y	u	y	i	i	ɛ	u	i	i	u	u	ʊ	y	i	i
124	i	ɪ	i	æ	ɛ	y	v	y	ɔ	v	i	v	i	y	i	i	i	ɛ	u	v	i	o	ɔ	y	i	y
127	u	i	i	i	y	o	i	i	i	i	i	i	ɔ	i	i	i	e	i	i	i	i	i	i	i	i	i
130	w	w	i	ɛ	ɛ	ɛ	ɛ	ɛ	w	u	w	æ	w	w	w	w	e	ɛ	y	w	i	e	ɛ	e	w	w
133	i	œ	o	i	o	o	i	o	i	i	y	i	œ	i	œ	i	o	œ	o	i	i	o	y	i	y	i
135	i	ɪ	i	i	y	v	i	i	i	i	i	i	i	i	i	i	e	i	y	i	i	i	y	i	i	o
138	w	i	y	y	y	y	i	i	i	i	i	i	i	i	i	y	e	i	i	y	y	i	i	y	y	i
141	ɛ	ɪ	æ	ɪ	æ	v	ɪ	ɪ	æ	v	ɛ	ɛ	æ	v	ɪ	ɪ	ɛ	ɪ	ɛ	ɪ	æ	ɪ	ɪ	ɛ	ɪ	æ
144	e	i	i	i	o	o	i	y	i	i	i	i	ɔ	æ	æ	o	e	ɛ	i	i	ɛ	i	i	w	i	y
147	w	w	i	i	y	y	i	y	y	v	i	i	æ	y	i	o	w	i	y	i	y	i	æ	i	i	i
150	i	i	i	i	ɪ	y	ɛ	i	i	u	i	i	ɛ	ɔ	ɪ	y	ɛ	i	u	y	i	i	i	o	i	ɪ
153	ɔ	u	y	y	y	y	y	y	y	y	y	ɪ	y	y	ɔ	y	y	ɔ	y	y	ɪ	y	æ	y	y	y
156	e	ɪ	i	æ	ɛ	y	e	e	e	æ	æ	e	ɛ	y	æ	æ	e	ɛ	æ	æ	e	e	æ	e	ɪ	æ
159	ɪ	ɪ	y	ɪ	ɛ	ɛ	u	u	ɔ	y	w	i	i	y	i	i	e	e	v	ɪ	o	o	ʊ	u	y	y
162	i	i	i	i	ɛ	ɛ	i	i	i	i	i	i	i	ɛ	i	ɔ	ɛ	ɛ	i	i	i	i	i	i	i	i
165	i	e	i	ɛ	w	æ	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i
168	i	e	y	i	y	y	y	i	y	i	i	y	y	y	i	i	y	y	y	i	v	i	i	y	y	y
171	i	i	i	i	y	o	y	y	i	y	w	y	ɔ	i	i	i	ɛ	i	ɔ	i	i	y	i	y	ɪ	y
174	w	e	y	y	o	y	0	y	y	y	y	v	y	ɛ	y	æ	y	y	y	y	o	y	y	y	y	y
177	i	i	i	i	w	ɛ	i	i	i	y	i	i	ɔ	y	ɪ	i	i	e	i	i	i	i	y	i	i	i
180	i	œ	i	æ	o	y	i	y	ɔ	i	i	i	y	i	i	i	y	e	y	u	y	æ	o	i	i	o
183	i	e	i	i	o	e	i	i	i	i	i	i	i	i	i	i	i	i	i	i	o	i	i	i	i	i

186	i	i	i	i	ε	u	i	i	i	i	i	i	u	i	i	i	i	i	i	i	i	i	i	y	i	i
189	e	i	i	ɪ	ε	y	i	o	i	i	i	i	ɔ	æ	i	i	i	i	i	i	i	i	i	i	i	i
202	i	i	i	i	ε	ε	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i
205	e	i	i	y	e	e	e	e	e	e	e	e	e	y	e	i	i	i	e	e	ε	e	e	i	ε	e
208	i	ɪ	i	y	w	y	y	i	i	u	i	i	y	y	i	i	i	e	y	i	i	i	i	i	w	w
211	æ	o	y	æ	ε	ε	e	e	y	e	w	w	æ	y	y	æ	e	e	w	o	æ	o	o	i	æ	e
214	i	e	i	i	y	y	i	u	i	y	i	i	y	i	i	i	i	i	i	u	y	i	u	y	i	i
217	i	œ	i	i	ɔ	o	i	i	i	i	i	i	ɔ	æ	i	o	i	i	i	i	i	o	i	i	i	i
220	i	i	i	i	ε	y	i	y	i	æ	i	i	æ	æ	ɔ	i	e	ɔ	ε	i	i	i	i	i	e	y
223	i	i	y	ε	ε	ε	y	y	i	i	i	i	æ	i	i	i	ε	ε	i	i	i	i	i	i	i	i
226	w	o	y	ɔ	ɔ	o	y	y	i	y	i	i	æ	æ	o	o	i	ɪ	i	i	i	y	y	i	y	y
229	i	e	y	y	y	y	i	æ	u	y	y	y	y	y	i	ɪ	i	i	æ	i	i	i	æ	y	ɔ	æ
231	w	u	u	u	u	w	y	y	i	v	i	i	ɔ	ɔ	i	o	e	i	i	i	u	o	o	y	i	i
233	i	e	i	i	ε	ɪ	ɪ	i	i	i	o	i	i	i	i	e	e	i	u	i	i	i	i	i	i	i
238	i	i	i	ε	y	æ	u	y	w	u	œ	i	y	ε	æ	w	e	ɪ	y	u	o	y	o	i	i	y
241	w	u	i	ɔ	ε	y	i	y	i	i	y	i	ɔ	ɔ	ɔ	ɔ	i	ε	i	i	o	i	i	o	i	i
244	i	i	i	i	w	o	i	i	i	i	i	i	i	ɔ	ɔ	ɔ	i	i	i	i	i	i	i	i	i	i
247	i	i	y	i	ε	ε	œ	i	i	i	i	œ	ε	i	i	i	y	i	y	œ	i	e	y	i	i	y
251	i	u	y	i	y	æ	i	u	i	i	i	i	v	æ	i	i	i	i	i	i	i	i	i	i	i	i
254	i	u	i	i	e	o	i	i	i	i	i	y	i	i	i	i	ε	e	i	i	i	i	i	y	o	y
257	i	i	i	i	0	u	i	i	i	i	i	i	i	y	i	i	i	i	i	i	i	i	i	i	i	i
260	o	o	æ	ε	ɔ	ε	i	æ	i	i	i	o	o	y	ɔ	o	e	ε	i	i	e	o	i	i	o	o
263	i	e	y	y	e	e	œ	œ	w	i	i	i	e	i	e	e	e	e	ɪ	i	e	i	o	u	e	e
266	i	i	i	i	0	y	i	i	i	i	i	i	i	y	i	i	i	i	i	i	i	i	i	i	i	i
269	i	ɪ	i	i	u	u	i	i	u	i	i	i	æ	i	i	i	i	i	i	u	i	i	i	i	i	i
272	i	i	i	i	y	y	i	i	i	i	i	i	i	i	y	i	y	i	i	y	i	i	i	y	i	i

Appendix IV

List of *-ity* Words

The following is a list of English words ending in *-ity*. The words are grouped together according to the pronunciation of the vowel immediately preceding *-ity*. In each group, the words are arranged alphabetically *backwards*. The words are mainly taken from Dolsby and Resnikoff (1967), and supplemented by those appearing in Stillman (1965) and *Webster's Third International Dictionary*. Those found in Stillman (1965) and not in Dolby and Resnikoff (1967) are marked '*'. Those found in neither but are listed in *Webster's Dictionary* are marked '&'. The numbers after the words are the frequencies of occurrence according to Carroll *et. al.* (1971) (plurals included).

[ɪ] (N=616) 2200

-icity words (N=66)	511
-bility words (N=355)	799
-ility words (N=47)	151
dimity	
*limity	
sublimity	
longanimity	
pusillanimity	
magnanimity	2
unanimity	
*sanctanimity	
equanimity	
parvanimity	
*pseudonimity	
intimity	
proximity	4
*anonymity	
synonymity	
dignity	49
indignity	
condignity	
malignity	
benignity	
vicinity	30
*finity	
affinity	4
*diffinity	
infinity	9
virginity	

salinity	11
*felinity	
*masculinity	
feminity	
*caninity	
femininity	2
supinity	
peregrinity	
trinity	7
Latinity	
*consanguinity	
*exsanguinity	
patavinity	
divinity	6
concinnity	
inconcinnity	
serendipity	
equilibrity	
queerity	
jequirity	
*ubiquity	
*obliquity	
*iniquity	2
*antiquity	8
*longinquity	
*propinquity	
*acclivity	
*declivity	
*proclivity	
*privity	
*passivity	

*impassivity	
*compassivity	
*emissivity	
&creativity	11
*negativity	
relativity	18
*correlativity	
*nativity	
*alternativity	
*activity	452
inactivity	2
*retroactivity	
*objectivity	
subjectivity	
*electivity	
collectivity	
*connectivity	
instinctivity	
*inductivity	
*conductivity	
*productivity	7
*reproductivity	
reluctivity	
sensitivity	14
positivity	
retentivity	
*motivity	
*captivity	16
*receptivity	
*perceptivity	
susceptivity	
*festivity	13
&resistivity	4
*fixity	
prolixity	

[æ] (N=251) 845

*rabbity	
*bibacity	
dicacity	
efficacity	
inefficacity	
perspicacity	
pervicacity	
procacity	
edacity	
mendacity	
mordacity	
audacity	
sagacity	6
fugacity	
nugacity	
salacity	
*contumacity	
tenacity	2
pugnacity	
minacity	
pertinacity	
*saponacity	
capacity	72
incapacity	
rapacity	
opacity	
feracity	
veracity	
voracity	
carnivoracity	
sequacity	
loquacity	
vivacity	2
-ality words (N=191)	337
amity	
calamity	3
urbanity	
inurbanity	
*volcanity	
*mudanity	
profanity	
*paganity	
*organity	
Christianity	50
*gigmanity	
humanity	27
inhumanity	
inanity	
sanity	4
disensanity	
insanity	
vanity	13
alacrity	
sanctity	3
scantity	
*cavity	67
*concavity	2
*gravity	259
*pravity	
*depravity	
*suavity	

[ɔ] (N=142) 1256

probity	
improbity	
precocity	
docity	
velocity	62
ferocity	6

reciprocity	
atrocity	
*neurocity	
paucity	
raucity	
oddity	5
*quoddity	
commodity	22
incommodity	
discommodity	
quality	367
equality	43
inequality	74
*coequality	
jollity	
polity	
insopolity	
*interpolity	
frivolity	2
comity	
deformity	4
difformity	
uniformity	9
*multiformity	
informity	
conformity	4
inconformity	
nonconformity	
*unconformity	
disconformity	
abnormity	
enormity	2
mediocrity	
authority	167
meliority	
seniority	
juniority	
*inferiority	6
superiority	24
deteriority	
*anteriority	
interiority	
posteriority	
*exteriority	
priority	11
majority	122
minority	33
sonority	
sorority	
falsity	
-osity words (N=85)	106
*quantity	187

[ε] (N=113) 739

scarcity	6
*rubedity	
heredity	24
fidelity	11
infidelity	2
supremity	
extremity	6
enmity	8
obscenity	
lenity	
amenity	5
serenity	8
indemnity	
solemnity	4
perennity	
barbarity	
solidarity	4
*rectilinearity	
*curvilinearity	
*vagarity	
vulgarity	
charity	22
*uncharity	
familiarity	13
peculiarity	7
clarity	26
hilarity	
*similarity	68
*dissimilarity	
pupilarity	
capillarity	
*molarity	
polarity	11
*bipolarity	
exemplarity	
*globularity	
*piacularity	
*vernacularity	
*molecularity	
secularity	
*orbicularity	
*perpendicularity	
particularity	
*jocularity	
circularity	
*vascularity	
*muscularity	
*grandularity	
regularity	11
irregularity	8

angularity	
*triangularity	
*rectangularity	
singularity	
popularity	37
*unpopularity	2
insularity	
*peninsularity	
parity	2
*gemmiparity	
*omniparity	
scissiparity	
*fissiparity	
*multiparity	
viviparity	
*oviparity	
*ovoviparity	
imparity	
disparity	2
rarity	4
muliebrity	
celebrity	7
incelebrity	
*tenebrity	
sincerity	7
insincerity	2
procerity	
ferity	
legerity	
celerity	
temerity	
asperity	
prosperity	30
alterity	
posterity	6
austerity	2
dexterity	3
*ambidexterity	
indexterity	
verity	
severity	4
integrity	11
disintegrity	
density	112
condensity	
immensity	
propensity	
intensity	68
extensity	
*necessity	63
*entity	6
*identity	85
*nonentity	
&equity	2
&inequity	
*longevity	
*levity	
*brevity	3
complexity	29
perplexity	6
duplexity	
connexity	
convexity	2

[uw] (N=51)	847
caducity	
nudity	
*rudity	
crudity	
seculity	
credulity	
incredulity	4
garrulity	
unity	70
triunity	
jejunity	
munity	
immunity	10
community	519
intercommunity	
discommunity	
impunity	6
disunity	4
importunity	
opportunity	203
inopportunity	
salubrity	
insalubrity	
*acuity	
*vacuity	
*conspicuity	
*perspicuity	
imperspicuity	
*innocuity	
*circuity	
*promiscuity	
*assiduity	
*ambiguity	2
*contiguity	
incontiguity	
*exiguity	
*superfluity	
*ingenuity	18
disingenuity	
*strenuity	
*tenuity	

*continuity	7
*incontinuity	
discontinuity	
*annuity	
*congruity	
*incongruity	2
*fatuity	
*gratuity	
*perpetuity	2
*tortuity	
[iy] (N=27)	12
caecity	
cecity	
haecceity	
deity	12
velleity	
diathermaneity	
contemporaneity	
extraneity	
spontaneity	
homogeneity	
heterogeneity	
femineity	
omneity	
personeity	
glabreity	
corporeity	
incorporeity	
aureity	
seity	
gaseity	
proseity	
ipseity	
perseity	
multeity	
betweenity	
crebrity	
obesity	
[ɚ] (N=23)	392
acerbity	
surdity	
absurdity	2
infirmity	6
*confirmity	
*modernity	2
maternity	
paternity	
compaternity	
fraternity	9
confraternity	

quaternity	
eternity	8
coeternity	
*sempiternity	
alternity	
subalternity	
externity	
taciturnity	
diuturnity	
adversity	2
diversity	18
university	345
[ʌ] (N=13)	0
*moribundity	
fecundity	
infecundity	
*rubicundity	
jocundity	
injucundity	
profundity	
*immundity	
*obtundity	
rotundity	
*orotundity	
nullity	
insulsity	
[ʊ] (N=10)	149
security	80
insecurity	4
obscurity	4
demurity	
purity	11
impurity	17
maturity	33
prematurity	
*immaturity	
futurity	
[ar] (N=2)	13
tardity	
varsity	13
[ey] (N=1)	0
*laity	
[ow] (N=1)	0
egoity	

Appendix V

List of Irregular Past Forms

The following is a list of past forms of irregular verbs in English which bear vowel change relations with their present tense counterparts. Invariant forms, marked with '*', are also included. The words are mainly taken from Quirk *et. al.* (1972). The figures following each word is the frequencies in Carrol *et. al.* (1970). The words are grouped together according to the pronunciation of the main vowel, and are ordered according to the number of words observed in each vowel category. Within each vowel category, the words are arranged alphabetically from the last letter of the word forward. Those words which are not observed in Carroll *et. al.* are not listed.

[ɛ] (N=33)	35055
read	3057
*spread	531
fed	182
led	598
bled	7
fled	79
*shed	131
sped	38
bred	22
said	15309
held	1049
fell	790
bet	157
*let	2176
met	433
*set	3572
*upset	108
*wet	418
left	2885
cleft	12
bereft	3
dealt	21
felt	1231
knelt	59
dreamt	3
leant	5
meant	539
leapt	10
kept	1131
slept	200
crept	89
wept	49
swept	161

[ɔ] (N=21)	14381
trod	14
bore	89
tore	76
wore	320
swore	28
caught	793
taught	283
bought	598
fought	278
thought	2835
brought	1357
wrought	30
sought	94
got	2626
begot	2
forgot	225
shot	398
*cost	610
lost	820
saw	2900
forsaw	5

[ow] (N=19)	6188
sold	477
told	2028
foretold	2
rode	425
strode	26
spoke	512
broke	396
woke	133
awoke	54
stole	52
shone	119
chose	171
rose	461
wrote	877
dove	32
drove	361
strove	10
wove	29
froze	23

[ʌ] (N=18)	4049
hung	321
overhung	4
clung	54
flung	70
slung	22
strung	28
wrung	7
stung	27
swung	164
dug	182
struck	291
stuck	186
slunk	10
won	446
spun	65
*thrust	132
*cut	1757
*shut	283

[æ] (N=17)	6174
clad	18
forbade	14
rang	138
sprang	106
sang	267
drank	106
shrank	15
sank	87
swam	176
began	2491
ran	1374
overran	8
spat	18
sat	1138
*cast	145
*broadcast	41
*forecast	32

[ɪ] (N=15)	9633
*bid	38
did	7169
undid	8
outdid	3
hid	127
slid	108
*rid	139
bit	600
*fit	461
*hit	595
lit	92
*split	159
*slit	40
*spit	25
*quit	69

[ʊ] (N=11)	8461
stood	1387
withstood	3
understood	183
misunderstood	10
shook	420
forsook	3
took	2490
undertook	11
overtook	10
mistook	2
*put	3942

[uw] (N=9)	4257
blew	222
flew	403
slew	10
knew	2044
drew	361
withdrew	25
grew	847
threw	342
overthrew	3

[ey] (N=6)	9344
came	4914
became	1501
ate	440
gave	1534
forgave	4
lay	951
[aw] (N=4)	5204
bound	170
found	3362
ground	1511
wound	161
[ɚ] (N=3)	2639
heard	1988
*hurt	457
*burst	194
[iy] (N=1)	540
*beat	540

Appendix VI

List of Irregular Plural Forms

The following is a list of plural forms of irregular nouns in English. These plurals bear vowel change relations with their singular counterparts. Invariant forms, marked with '*', are also included. The list is taken from Quirk *et. al. (1972). The numbers after each word is the frequencies listed in Carroll et. al. (1970). The starred words are invariant forms.*

[ɪ] (N=5)	5100
*fish	1591
women	599
children	2575
*deer	332
*reindeer	3
[iy] (N=4)	3639
geese	82
teeth	541
*sheep	471
feet	2545
[ay] (N=3)	255
lice	18
mice	204
*pike	33
[aw] (N=3)	82
*grouse	16
*flounder	10
*trout	56
[ɛ] (N=2)	4098
bretheren	8
men	4090
[æ] (N=1)	210
*salmon	210

[uw] (N=1)	63
*moose	63
[ʌ] (N=1)	241
*duck	241
[ar] (N=1)	16
*carp	16
[ey] (N=1)	0
*plaice	0

Appendix VII

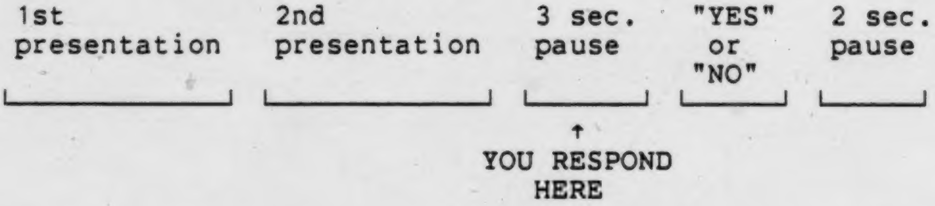
Instructions of the Concept Formation Test

In this experiment, you are going to play a game that will help us learn something about the way the English language works. You will hear a series of related word pairs. Some of the words are real English words, while others are artificially made up to sound like English words. An example of a real word pair is *describe-description* (*peace-pacify*). An example of a make-believe or nonsense pair is *extase-extasity* (*extase-extisity*).

Notice that in both cases the second word is related to the first, usually by means of an added suffix (e.g. *-tion* (*-ify*) and *-ity*). All of the nonsense pairs, in fact, will involve the addition of the suffix *-ity*, but the real words may show a variety of different patterns.

In **all** cases, however, a **vowel change** will also be involved (e.g. *describe-description*) (*peace-pacify*). In some of these word pairs there is a particular relationship between the **vowel sounds** of the two words, while in others there is no such relationship between the vowel sounds. You will hear each pair twice. After the second presentation of each pair, there is a three-second pause, then a voice on the tape will tell you whether or not this mysterious relationship between the vowel sounds exists in this pair: it will say "yes" if the pair has the property, and "no" if it does not. Your job is to figure out what it is that the "yes" pairs have in common, that the "no" pairs do not have, and respond accordingly by saying "yes" or "no" during the three-second pause.

Please try to respond to *every* item during the pause provided, even though you may have to guess randomly at the beginning. You can check your responses against the voice on the tape which will tell you the correct answer. You will know you have discovered the correct property of the words when your responses always match those of the voice on the tape. The format of each item is as in the diagram shown:



There are 108 items altogether. The items in the first half of the list all have the above format, which will help you become familiar with the task. In the second half, some of the items will have a "beep" sound to replace the "YES" or "NO" after the three-second pause. These are the **test items** to see if you are on the right track and to find out if you can deal appropriately with some new examples. You will not have to change your mode of response on these items, however, as you will continue to respond with "yes" or "no" during the pause.

Remember that you are paying attention to the relationship between the vowel sounds in the pairs of words. Your neighbors will be listening to different orders of presentation, so don't be influenced by their responses. Are there any questions?

(PLEASE STOP THE TAPE HERE.)

Answer these questions at the end of the experiment:
Did you figure out what this relationship is between the vowel pairs? Can you describe in a few words the nature of the relationship? (Write your answers on reverse side.)

List of stimuli used in concept formation test.

A. VS Task

Positive Tokens

Real Pairs

1. divine-divinity
2. rite-ritual
3. describe-description
4. wise-wisdom

5. explain-explanatory
6. vacant-vacuous
7. profane-profanity
8. grateful-gratitude

Nonsense Pairs

17. subkipe-subkipity
18. depide-depidity
19. embice-embicity
20. obtize-obtizity

21. probague-probaggity
22. surpafe-surpafity
23. extaze-extazity
24. defague-defaggity

9. exceed-excessive
10. deceive-deception
11. serene-serenity
12. please-pleasure

13. code-codify
14. joke-jocular
15. provoke-provocative
16. ferocious-ferocity

25. subguete-subguetity
26. enteep-entepity
27. surfeen-surfenity
28. conleece-conlecity

29. purtoce-purtocity
30. connofe-connofity
31. empobe-empobity
32. pregode-pregodity

Control Tokens

33. mind-mental
34. time-temporal
35. bind-bondage
36. find-found
37. domain-dominion
38. detain-detention
39. example-exemplify
40. propel-propulsion
41. peace-pacify
42. reason-rational
43. steal-stolen
44. seat-sit
45. solar-sun
46. pope-papal
47. appear-apparent
48. false-fallacy

49. enfipe-enfepity
50. enfipe-enfepity
51. condite-dondatity
52. extife-extaffity
53. envape-envipity
54. prelabe-prelibity
55. diskate-diskatity
56. surnade-surnedity
57. deneek-denackity
58. disveed-disvadity
59. purfeeze-purfizzity
60. proneef-proniffity
61. exdone-exdunnity
62. confote-confuttity
63. enkoce-enkoocity
64. purloke-purlookity

Test Phase

Reinforcement Tokens

Positive Tokens ('*' before items with beeps)

65. malign-malignant
66. *define-definitive

67. *nature-natural
68. sane-sanity

69. *receive-receptive
70. obscene-obscenity

71. cone-conical
72. verbose-verbosity

73. contibe-contibity
74. empize-empizzity

75. *pretave-pretavity
76. purdape-purdapity

77. proleet-prolettity
78. *exeel-exellity

79. degone-degonity
80. *defoce-defocity

Control (Negative) Tokens ('*' before items with beeps)

81. *law-legal
82. long-length
83. sustain-sustentive
84. genteel-gentility

87. *obzeed-obzadity
88. *subnike-subneckity
89. debave-debivity
90. envope-envuppity

85. strong-strength
86. *clear-clarity

Test Items (All items with beeps)

91. sound-sonic
92. astound-astonish

93. pronounce-pronunciation
94. abound-abundant

95. fool-folly
96. goose-gosling

97. youth-young
98. reduce-reduction

99. conjoin-conjunction
100. destroy-destruction

101. joy-jolly
102. cloister-closet

103. disnawk-disnokity

104. procawze-procuzzity

105. purvoosh-purvoshity

106. dezood-dezuddity

107. subcoid-subcuddity

108. predoil-predolity

B. AVS Task

1. peace-pacify
2. reason-rational
3. beat-batter
4. appear-apparent

5. deign-dignity
6. domain-dominion
7. gave-given
8. lame-limp

9. mind-mental
10. time-temporal
11. die-dead
12. delight-delectable

13. solar-sun
14. no-none
15. flow-flux
16. hoax-huckster

17. enteep-entapity
18. surfeen-surfanity
19. conleece-conlacity
20. subgueet-subgatity

21. probague-probiggity
22. defague-defiggity
23. surpafe-surpiffity
24. ensate-ensittity

25. subkipe-subkeppity
26. embice-embecity
27. dispime-dispemity
28. obtize-obtezity

29. purtoce-purtussity
30. obdoke-obduckity
31. dezope-dezuppity
32. empobe-empubbity

Control (Negative) Tokens

33. divine-divinity
34. find-found
35. bind-bondage
36. example-exemplify

49. enfipe-enfipity
50. procile-prosality
51. condite-condotity
52. extife-extiffity

37. vacant-vacuous
38. detain-detention
39. propel-propulsion
40. grateful-gratitude
41. serene-serenity
42. genteel-gentility
43. steal-stolen
44. deceive-deception
45. provoke-provocative
46. pope-papal
47. false-fallacy
48. long-length
53. envape-envapity
54. prelabe-prelabity
55. diskate-disketity
56. surnade-surnuddity
57. deneek-deneckity
58. disveed-disvedity
59. purfeeze-purfizzity
60. proneef-pronofity
61. exdone-exdoonity
62. confote-confotity
63. enkoce-enkocity
64. purloke-purlookity

Test Phase

Positive Reinforcement Tokens ('*' before items with beeps)

65. clear-clarify
66. *seat-sat
67. right-rectitude
68. slide-sled
69. *equate-equivalent
70. raise-risen
71. *stroke-struck
72. blow-bludgeon
73. *empize-empezzity
74. objite-objettity
75. *purdape-purdipity
76. subkale-subkility
77. *exeel-exality
78. subdeeve-subdavity
79. pretole-pretullity
80. enoke-enuckity

Control (Negative) Tokens ('*' before items with beeps)

81. malign-malignant
82. nature-natural
83. *receive-receptive
84. law-legal
85. *strong-strength
86. sustain-sustentive
87. obzeed-obzidity
88. *subnike-subnackity
89. debave-debevity
90. *endofe-endofity

Test Items (Same as VS Task)

4

Appendix VIII

Data from Concept Formation Test

"V" subjects took part in vowel shift concept; "A" subjects took part in anti vowel shift concept. Numbers in second column are the numbers of trials each subject took before reaching criterion. Those subjects who did not reach criterion are marked '99' in this column. In the responses, 1=YES, 2=NO 0=No response made. Items are ordered according to the list in Appendix VII.

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V101 32 12121210111112121121101111111111
        22122201122221222202112222010122
        1111211111111111 2221212222 111121212222 221121
V105 23 11212111111111111111111112211111
        222221122222222111222222222121222
        1112111111111111 2221222222 112211112122 121121
V109  2 11110121111111111110121111011111
        02222022222222221222222222222212
        1111111111111111 2222222222 112211212212 221121
V113  0 11111111111111111111111111111111
        22222222222222222222222222221222
        1111111111111111 2222222222 222211212222 022121
V117 20 1101011121111111101121101021111
        022220222222221122222222222202122
        1111111111112111 2221122201 222222112222 222122
V121 25 11111112121112111111221111111111
        12222122222222222122222222121222
        1111111111111111 2221222222 221212212212 221121
V125 23 11010111111122111101221111011111
        02222012222222120222222222122222
        1111111111112111 2221222222 222211212211 121221
V129 99 11112112111212121111112111211111
        22111121122122111211111110111121
        1121112111121111 2211212211 211121212122 111111
V133 99 12210212111112112111212122122121
        22221222211221121212222222112222
        1221112111222112 2221222222 222222212222 222221
V137 48 11110212121111112111211112221111
        12122221222222122222222222112221
        1111211111111111 2211222212 212221112212 122221
V141 99 22210112111111121101221111221111
        02221112222222210221212222121122 21
        1111111112121122 2211211122 122211122111 222221
V145 99 22111221112111122112122112211211
        12221211122222111122111122221211
        1111111111111112 2211222221 211222112112 111112
V149 20 11110111111111111110111112121111
        02222022222222222222222122221211
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         11111111111212111 1222222222 122211212212 221222
V153 47 12111211111122211111222112111112
        12121111122122111222212222111122
        11111111121112121 2121212212 111121111122 222112
V157 99 12221122211222112211122112111121
        22112211122222221222212221212121
        11211122111122111 2211222122 222221222222 121121
V161 40 11111211111211211111121111111111
        22222222222222220122222222222212222
        11112111111111111 2221222122 222211112212 221121
V165 13 11111111111111111121111111211111
        22222112222222222222222122111222
        11111110111111111 2222222222 121112111121 122121
V169 44 12111212211122111111112211111112
        22222212222222221222222122211212
        11111111111111211 2221221222 221222112212 222122
V202 40 12110212211111111201212121021111
        02122021122222211222212122121211
        11111111111111111 2222222222 112211112211 122121
V206 99 11111111111121111212121111112112
        21212221210222121112121221211122
        12112211222111111 2122221121 211222211122 212121
V214 99 12111211111211211111112212221121
        11211202112121122222112112111212
        11221111121112111 2211211222 211112212222 211121
V218 18 11110111111111122101111111011121
        02222022222222211121222222212 1222
        11111111111111111 2221212222 211211112212 122112
V222 41 12121212111122221221121211111112
        12122211111221121221112122212221
        12111121122112111 2212211212 211121222121 212111
V226 99 12011122211112111102212122021111
        02220022222222120220221222111121
        21121121111122201 2211221221 212122122211 222222
V230 99 12121112111222112211111112121111
        22221110222222211221122021111111
        21212121121111111 2221221121 222212212222 212211
V234 99 11121111211121111121122111121111
        12122111112222221221111211121111 21
        11112111211111111 2221222211 221221211222 121111
V238 40 11111212121122121211211221111122
        22222212221121222222212222112122
        21212111111112112 2222222212 221121222222 121211
V242 26 11111111111111121111211111111111
        22222212222222211222222222222112222
        11211111111111211 2202222221 212211212211 222121
V246  0 11111111111111111111111111111111
        20222222222222222222122222222211222
        11111111111111211 2222222221 222221112222 222122
V250 13 11111111111111111111112111111111111
        22222212222222221222222222222122222
        11111111111111211 2222222121 220122112212 222222
V254 26 11111121111111111111111111111121111
        22222222222222221222222222222211122
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         1111111111111211 2221222222 112211112211 212122
V258 47  11111111121112121211111111211111
         22221221222222112222122222112222
         2111111111111211 2221222222 212211111212 121121
V262 12  12111111211211111111121111111111
         22222221122222112222222222221122
         2111111111111211 2221222221 222222212222 221122
V266 38  11112111111112121121121111121211
         12122211122212112222212222111122
         1111211111111211 2221212222 221211112212 111122
V270 51  11211111121112111111111111221111
         22222212222222221122222222122111
         1111211111112211 2221222221 112221112212 222121
A303 99  11222122111222210111122112122122
         11111111212111111111112112122111
         2111111111112211 2212112221 211112112112 121111
A307 99  01212211111222211121121112122211
         21221121122222122111211122102111
         1101111112111222 2121201111 221212201111 111211
A311 99  12221222121222222121211212111211
         11111112111112211211221212112212
         2121122111121111 2211112112 222111212112 112112
A315 99  02221111211120111120111211111212
         10112121212121122122201212111222
         1111121111112111 2221111112 121112221121 212212
A319 99  11122110211121201112121211210221
         12212121212121112221211211210112
         1121221211211221 1121121121 111212111222 211221
A323 99  01222022111220222122202212222222
         10111201111111212221201022222212
         1101011221222221 1212101220 211121211212 121122
A327 99  01120000111000001122101121020101
         00112102110102100000202100020100
         1111111111111011 1212220222 221112101122 212211
A331 99  01212122122220121111200102222222
         10122001112011221211201201222122
         1221111211222221 1111201222 121111221122 221222
A335 50  21111211111211111112111111212122
         21112121211221212122222112211221
         1111211121111111 2221112112 222222221122 222212
A339 99  12211212212222122111122212112122
         21111111112222221122212222222111
         1222212121121211 1122211211 111122222222 121212
A343 99  11122112211121221111111112121121
         12122122122111211112211210111111
         2221112112212212 1121112211 211122122211 221222
A347 99  11211122022221021210121221212211
         12112221102222222222222022012121
         1221222212111111 1112222211 121122121222 221211
A351 88  11112212121221211111121221222211
         22221211221121112121211222221121
         1111111111211111 2222212222 011011120010 220102
A355 99  11111211111210221111212121111111
         21122222121221122212221122211211
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        110111121112211l 0221122221 211122211121 222112
A359 99 11211112211111221112121112222222
        22112220211111121122121121121112
        211111112111l1121 2221122112 222122221222 221222
A363 99 01111121222211210222221221221222
        20211111111111222112122221212112
        2222122111210112 1022222112 121112111022 222212
A367 99 02222122222222221221122212221212
        22211111112122222122211112122122
        1222101212121212 1112211121 212122211212 121122
A371 99 11112111111121211111121211211212
        21112121202121112221211122111122
        1112112111112121 2121212122 112121112122 121222
A404 99 01221121221121121111121121201111
        10222221111211122211201221111121
        1111011012212212 1111112122 111111121112 021211
A412 99 12222122212222212122112112111122
        22212211112112222122112112112212
        1111111112221121 1212222212 122221111211 112122
A416 99 01222211112221222122212112222212
        10211121111121222211201211122112
        1221212112112222 1111121221 211221211112 122222
A424 99 12121222122222112211112111222122
        11211111121221222121111211212111
        2111111222211221 1121221121 221122212122 221221
A428 99 10122122211102211112011111111111
        11111111111111021111111111101111
        1111211212111111 2221112121 122111211211 111221
A432 45 01111211211112111111111111111111
        20112112222221222112212112111122
        1111111111111111 2121111112 221122221122 211212
A436 99 11212112111112222122222222222222
        21211121121111212222212222222212
        1122122222222222 2111112222 111111111122 222222
A440 99 12112211112222222222112122112121l
        12112221111111211121111221122111
        2111111111111122 2221122122 112111111112 111111
A444 99 22122222221221122222222111102111
        22221121111122221111112112221112
        1220211221222011 1012012221 212111211112 212211
A448 99 02111112111122212222020122201222
        10211222121111212110221222222212
        0200112201202201 1112212222 211121221122 212111
A452 99 01111211111111102111121112221222
        20112111221211211212202111222121
        1111211221112111 1221111122 122111221112 121211
A456 99 12212122121111221121121111221212
        11121111112111111111112111121122
        1222221211111221 1122111211 111111111112 112112
A460 99 01121221222210122112111222212112
        11021221122222112121121122202112
        1222222211111211 2222221211 222222222222 111111
A464 99 11111111111111111112111111111112
        22121121211211212111221112211022
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          1111111111111111 2211111121 122122121121 111121
A468 45 01111111121120211111121111211111
          20112122212122222121201122111221
          2111111111111111 2222111112 221122222122 212122
A472 99 12212221122222111121111021111121
          11112022211222121121212112211112
          1121111212121222 1111121121 221112111112 222221
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Appendix IX

Answers by Subjects to the Questions in

Concept Formation Test

Answers written by subjects to the following questions:

"Did you figure out what this relationship is between the vowel pairs? Can you describe in a few words the nature of the vowel pairs?"

("V" subjects are VS subjects; "A" subjects are AVS subjects. Only the answers by those who reached criterion are shown here. Notice that subjects V246 and V266 referred specifically to 'letters' and 'spelling'.)

V101 'Vowel change from a long one to a short one.'

V105 'In the first word the vowel sound was long and in the second word there was the short version of the vowel sound.... A few that were hard to figure out, in that I wasn't sure if they were just supposed to follow the long/short pattern, were some which had variations of blended vowel sounds, e.g. OU, OO; they follow a pattern in that they are both from the same general family of vowels, but they aren't opposite or alike, just remotely similar.'

V109 'The first word had a long vowel sound and the second had the same vowel but it was short.'

V113 'Long vowel sounds in a word change into short vowel sounds.'

V117 'The first word of the pair has a long vowel sound and the second has a shorter vowel sound.'

V121 'The vowels were the same but sounded different.'

V125 'The relationship exists in a change usually from the long sound of the vowel to the short sound. E.g. *sain*[sic.]-*sanity*.'

V137 'The relationship is whether the vowels stay the same in both forms, even if the sound changes.'

V149 (Didn't seem to be able to describe the relationship, s.w.)

V153 'When the word switches were smooth.'

V161 'The vowel sounds were related in being either long or short in both words. ō to ŏ or ī to ī. The unrelated ones were usually a change from one vowel to another or a combination of 2 vowels to one. E.g. OU to A or A to E.'

V165 'The second word's vowel sound is opposite the first. That is, the first is long so the second word should have a short vowel sound.'

V202 'The nature is in the actual vowel and not the sound.'

V218 'I could not figure out the relationship. It seems that where there was a major change in vowels there was no relationship.'

V222 'The way in which the words are changed.' (Not quite clear what is meant, s.w.)

V238 'I cannot see a relationship.'

V242 'Between long and short vowel sounds.'

V246 'In the first word the vowel sound is long, e.g. ē as in *beet*. In the second word the vowel sound is short, e.g. ĕ as in *let*... The sound was caused by the same letters being sounded differently.'

V250 'If the vowel sounds were of the same vowel, e.g. short "A" long "A", then the answer was "yes", otherwise it was "no".'

V254 'The answer is "yes" when the vowel has its pronunciation changed (i.e. *serēne, serĕnity*). The answer is "no", when the vowel is completely changed (i.e. destroy, destruction). The one problem I had was whether or not I was to say yes or no to changes such as oi→o.'

V258 'The relationship was whether or not the vowel itself changed. "Yes" if the vowel stayed the same, "no" if it changed.'

V262 'They are the same vowel or combination of vowels only pronounced differently.'

V266 'Words are related by their hard and soft vowel sounds. If they have the same spelling but different vowel sounds then I said they were related.'

V270 '"Yes", when vowel is the same but its pronunciation is different. "No", when vowel changes.'

A335 'If the dominating sound changed from the first to the second you respond with "yes". If it did not change the response was "no".'

A432 'When the same vowels were used in both words, but they maybe were pronounced differently, the answer was "no". When two different vowels were used, the answer was "yes".'

A468 'When the word that is first said has a long vowel sound, not only does that vowel changes but it becomes short.'

Appendix X

Results of Judgement Test for Word Pair Relatedness

The following is the list of word pairs which were given to a group of 59 university students for relatedness judgement. They were asked to judge whether the first member of the word pair is "contained in" the second, and indicate their judgement on a 1 to 5 scale: 1 being low on the relatedness, and 5 being high. The judgement ratings, given in frequencies, and the average rating for each pair are reported on the right column.

	PAIR	1	2	3	4	5	AVERAGE
1	lean-ladder	40	11	4	1	3	1.58
2	stroke-struck	17	18	7	11	6	2.51
3	cook-cookie	10	12	7	10	20	3.31
4	pronounce-pronunciation	2	1	2	11	43	4.56
5	rub-rubber	15	14	3	11	16	2.98
6	awe-awful	10	17	8	11	13	3.00
7	law-legal	9	13	10	19	8	3.07
8	price-precious	20	15	5	14	5	2.47
9	crane-cranberry	40	10	4	3	2	1.59
10	food-feed	11	14	10	14	10	2.97
11	people-populate	12	15	6	18	8	2.92
12	appear-apparent	4	10	4	21	20	3.73
13	write-rewrite	3	1	0	9	46	4.59
14	fly-fledgling	18	17	11	10	3	2.37
15	sane-sanity	1	1	3	10	44	4.61
16	raise-risen	4	11	7	18	19	3.63
17	delight-delectable	8	19	14	15	3	2.76
18	know-acknowledge	5	3	3	30	18	3.90
19	cup-cupboard	3	3	0	20	33	4.31
20	pope-papal	9	4	7	19	20	3.63
21	holy-holiday	5	8	6	19	21	3.73
22	verbose-verbosity	1	1	3	15	39	4.53
23	creep-cripple	29	16	7	7	0	1.86
24	lace-necklace	5	8	6	24	16	3.64
25	flow-flux	15	15	17	9	3	2.49
26	mind-mental	10	8	12	22	7	3.14
27	bind-bondage	7	6	10	21	15	3.53
28	gypsy-Egyptian	30	17	7	4	1	1.80
29	fable-fabulous	27	11	6	12	3	2.20
30	beard-barber	21	18	6	12	2	2.25
31	false-fallacy	4	6	4	24	21	3.88

32	neat-natty	27	17	12	3	0	1.85
33	erase-eraser	1	2	0	9	47	4.68
34	pull-pulley	3	6	2	14	34	4.19
35	live-liver	26	13	7	10	3	2.17
36	game-gimmick	22	15	12	9	1	2.19
37	right-rectitude	21	14	11	10	3	2.32
38	convey-convection	16	15	12	10	6	2.58
39	no-none	7	9	4	18	21	3.63
40	obscene-obscenity	1	0	2	9	47	4.71
41	number-numerous	3	6	4	17	29	4.07
42	give-given	1	0	0	12	46	4.73
43	steep-steeple	14	15	4	17	9	2.86
44	joke-jocular	12	16	7	17	7	2.85
45	wild-bewilder	21	22	7	4	5	2.15
46	mouse-mustard	49	6	2	0	2	1.31
47	explain-explanatory	2	3	3	19	32	4.29
48	mist-muggy	24	15	11	8	1	2.10
49	bash-bashful	10	11	4	4	30	3.56
50	law-lawyer	3	2	3	5	46	4.51
51	moon-month	17	7	6	20	9	2.95
52	rite-ritual	2	3	3	23	28	4.22
53	rich-reign	29	23	2	3	2	1.75
54	receive-receptive	4	5	4	23	23	3.95
55	code-codify	5	5	9	15	25	3.85
56	lose-lost	4	6	1	25	23	3.97
57	bird-birdhouse	1	4	0	6	48	4.63
58	clear-clarify	2	7	9	18	23	3.90
59	teach-teacher	1	1	0	5	52	4.80
60	wonder-wonderful	1	7	2	11	38	4.32
61	deign-dignity	10	17	22	9	1	2.56
62	heave-heavy	8	5	12	27	7	3.34
63	die-dead	6	7	10	16	20	3.63
64	bone-bonnet	37	15	4	0	3	1.59
65	spin-spider	27	13	8	6	5	2.14
66	yoga-yogurt	41	12	3	2	1	1.47
67	sound-sonic	9	9	9	21	11	3.27
68	fool-folly	14	9	10	15	11	3.00
69	hide-hideous	18	15	8	10	8	2.58
70	detain-detention	4	6	2	22	25	3.98
71	find-found	6	12	4	19	18	3.53
72	hoax-huckster	15	14	15	13	2	2.54
73	sustain-sustentive	3	14	20	16	6	3.14
74	sit-sat	10	7	6	17	19	3.47
75	louse-lousy	9	8	13	18	11	3.24
76	provoke-provocative	1	4	4	19	31	4.27
77	quiet-quietly	1	0	1	2	55	4.86
78	hand-handkerchief	5	4	7	16	27	3.95
79	wild-wilderness	2	1	2	16	38	4.47
80	fierce-ferocious	2	7	8	16	26	3.97
81	message-messenger	5	3	4	19	28	4.05
82	cone-conical	7	3	8	17	24	3.81
83	please-pleasure	2	4	3	20	30	4.22
84	divine-divinity	3	3	2	14	37	4.34
85	fry-Friday	41	11	2	4	1	1.53

86	domain-dominion	10	6	7	29	7	3.29
87	pose-dispose	16	12	6	9	16	2.95
88	genteel-gentility	1	8	7	25	18	3.86
89	berry-strawberry	4	2	2	19	32	4.24
90	sheep-shepard	4	4	9	23	19	3.83
91	astound-astonish	3	7	4	25	20	3.88
92	conjoin-conjunction	6	13	17	16	7	3.08
93	break-breakfast	7	9	5	12	26	3.69
94	dirt-dirty	2	1	0	7	49	4.69
95	hand-handle	6	3	6	18	26	3.93
96	joy-jolly	11	10	6	26	6	3.10
97	render-surrender	9	13	8	18	11	3.15
98	ear-eerie	46	7	2	1	3	1.44
99	reduce-reduction	2	2	2	16	37	4.42
100	sit-seat	6	15	9	18	11	3.22
101	time-temporal	12	10	11	19	7	2.98
102	dog-doggie	1	1	3	9	45	4.63
103	young-youth	4	10	5	24	16	3.64
104	lame-limp	15	15	6	17	6	2.73
105	sublime-sublimity	1	2	3	14	39	4.49
106	serene-serenity	1	0	1	13	44	4.68
107	describe-description	1	3	3	15	37	4.42
108	vacant-vacuous	8	14	17	13	7	2.95
109	blow-bludgeon	20	11	14	10	4	2.44
110	propel-propulsion	0	5	8	23	23	4.08
111	beat-batter	16	15	8	11	9	2.69
112	peace-pacify	10	11	9	20	9	3.12
113	exceed-excessive	3	4	3	28	21	4.02
114	closet-cloister	25	8	9	12	5	2.39
115	profane-profanity	1	2	1	10	45	4.63
116	hunger-hungry	5	3	1	15	35	4.22
117	equate-equivalent	7	6	10	19	17	3.56
118	destroy-destruction	5	2	3	24	25	4.05
119	goose-gosling	5	6	8	18	22	3.78
120	sweat-sweater	14	12	4	9	20	3.15
121	holy-Holloween	27	8	2	18	4	2.39
122	grateful-gratitude	6	4	7	20	22	3.81
123	last-least	15	18	5	13	8	2.68
124	give-gave	6	9	8	18	18	3.56
125	wind-weather	30	15	8	5	1	1.85
126	example-exemplify	7	10	6	18	18	3.51
127	define-definitive	4	6	4	16	29	4.02
128	strong-strength	7	9	3	23	17	3.58
129	dog-puppy	31	14	2	7	5	2.00
130	malign-malignant	9	7	6	9	28	3.68
131	long-length	10	10	6	19	14	3.29
132	gold-gilded	18	12	9	17	3	2.58
133	nature-natural	2	0	4	23	30	4.34
134	sun-solar	14	8	5	17	15	3.19
135	wise-wisdom	1	3	3	14	38	4.44
136	bug-buggy	27	10	3	8	11	2.42
137	steal-stolen	6	7	7	23	16	3.61
138	abound-abundant	14	10	6	17	12	3.05
139	reason-rational	15	9	9	18	8	2.92

140	bloom-blossom	10	12	6	22	9	3.14
141	fierce-ferocity	4	7	6	22	20	3.80
142	deceive-deception	5	1	7	17	29	4.08
143	slip-slipper	13	13	5	10	18	3.12
144	fly-feather	34	17	6	2	0	1.59
145	tame-timid	18	14	5	15	7	2.64
146	adjust-adjustment	2	0	0	6	51	4.76
147	sled-slide	17	17	3	17	5	2.59
148	skin-skinny	10	13	4	7	25	3.41
149	wagon-carpenter	45	12	0	0	2	1.34
150	cat-kitty	27	11	3	10	8	2.34